Annual Report of the

Board of Scientific Advice for India

for the year 1915-16

Calcutta
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Name.	Appointment.
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Colonel H. T. Pease, C.I.E., M.R.C.V.S.	Principal, Punjab Veterinary College.
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H. H. Hayden, Esq., C.I.E., D.Sc., B.A., B.A.I. (T.C.D.), F.G.S., F.A.S.B.	Director of the Geological Survey of India.
The Hon'ble Surgeon-General Sir Charles Pardey Lukis, K.C.S.I., M.D., F.R.C.S., I.M.S.	Director-General, Indian Medical Service.
The Hon'ble Mr. F. C. Rose, M.I.C.E.	Secretary to the Government of India, Public Works Department.
Sir Alfred Bourne, K.C.I.E., F.R.S.	Director, Indian Institute of Science.
Major A. T. Gage, I.M.S.	Director of the Botanical Survey of India and Secretary, Board of Scientific Advice.

List of Sub-Committees.

Sub-Committee A.—(*Meteorology, Terrestrial Magnetism and cognate subjects*).

1. The Surveyor-General of India (Chairman);
2. The Director-General of Observatories;
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman);
2. The Inspector-General of Forests;
3. The Agricultural Adviser to the Government of India.

Sub-Committee C.—(*Soils and Manures*).

1. The Agricultural Adviser to the Government of India (Chairman);
2. The Director, Geological Survey of India;
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

1. The Inspector-General of Forests (Chairman);
2. The Agricultural Adviser to the Government of India;
3. The Director, Botanical Survey of India.

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1. The Principal, Punjab Veterinary College (Chairman);
2. The Agricultural Adviser to the Government of India;
3. The Superintendent of the Indian Museum.

Sub-Committee F.—(*Libraries*).

1. The Director-General of Observatories (Chairman);
2. The Surveyor-General of India;
3. The Director, Geological Survey of India;
4. The Superintendent of the Indian Museum.

ANNUAL REPORT FOR 1915-16.

ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

1915-16.

SUMMARY OF PROCEEDINGS.

Thirtieth Meeting held at Simla on the 15th May 1916.

The programmes of the work to be done by the various Scientific Departments in 1916-17 were discussed and accepted.

The Board recommended that the Indian Science Congress should meet once a year and that travelling allowance should be granted for the next three annual meetings to all Government servants attending the Congress.

A question raised by the Surveyor-General of India, of co-ordinating the Scientific Libraries in India, was referred to Sub-Committee F (Libraries) for discussion and for the formulation of specific proposals.

The Board considered a suggestion made by the Principal, Punjab Veterinary College, regarding the diagnosis of Dourine and recommended that arrangements should be made for carrying out tests for the diagnosis of this disease at Muktesar or any other convenient centre.

Thirty-first Meeting held at Delhi on the 27th November 1916.

The Board nominated Mr. H. G. Carter, Officiating Director, Botanical Survey of India, to officiate as Secretary to the Board during the absence on leave or on special duty of Major A. T. Gage, I.M.S.

The Board passed the draft Annual Report but decided to discuss at the next meeting the question whether the form of the Report could not be revised with advantage, and in the meantime to invite members to formulate proposals for its improvement. It was also decided to consider at the next meeting a suggestion made by Sir Alfred Bourne that an account of the work done by the Science Institute of Bangalore should be incorporated in the Board's Annual Report.

A proposal was considered that the Board should co-operate in a scheme for the organisation and development of Industrial Research in the British Empire. The Board considered that its organisation would require some modification before it could successfully co-operate in this scheme, and it decided to appoint a Sub-Committee to draw up detailed proposals.

The Board resolved to record the report of Sub-Committee F in which it was recommended that the first step required for the co-ordination of scientific libraries was the preparation of a list of the scientific periodicals in all the public libraries in India and in libraries attached to colleges and other important institutions. The Board was informed that the Government of India were making arrangements for the compilation of the desired catalogue.

APPLIED CHEMISTRY.

PART I.—AGRICULTURAL CHEMISTRY.

BY

J. SEN, M.A., F.C.S.,

Officiating Imperial Agricultural Chemist.

SOILS.

Soil survey in Madras.—Harrison and Viswanath have made a survey of the soils of the Guntur delta. The nitrogen content of these soils is low and the introduction of special manurial methods with the object of rectifying this should lead to great benefit. The results of the survey indicate the great effect of river silt in modifying the manurial character of the soil of the delta. The silt of the Kistna river is rich in lime, magnesia, total potash and phosphoric acid and the soils under its influence therefore materially differ from the coastal soils and those in the centre of the delta, which are of the poorest quality. These facts furnish a strong argument in favour of conservation of the silt of the Kistna river.

Burma soils.—Warth grew paddy in pots filled with soils from the Government farms in Burma. He found that there was no general agreement between the yield of paddy and the soil reaction or the content of any of the plant food materials in the soil. However, on arranging the soils in the order of the content of soluble silica (which is taken to represent sufficiently accurately the order of the permeability of the soils) he found a parallelism.

As to the effect of manure he found that the final crop weighings showed a great increase due to nitrogen in every case but the effect of phosphoric acid was marked only in those soils which were heavy. This effect of phosphoric acid was seen at a very early period (and was in fact most marked at that stage) but was maintained throughout the growth of the plant.

When lack of phosphoric acid in the soil was made good by manuring, the growth in all the soils became almost identical. This showed that the retarded development was due to an actual lack of phosphoric acid in the soils. The figures for "available" phosphoric acid, determined in the usual way by extraction with citric acid form no criterion for the amount of phosphoric acid available for the paddy crop. On the other hand a poor straw may be considered a sufficiently satisfactory index of lack of available phosphoric acid.

Warth is studying certain types of soil which at times produce very irregular growth of paddy. The acidity of these soils is said to be liable to

extraordinary fluctuations and he is investigating the nature and source of the acidity and its effect on the crop.

Reclamation of alkali soils.—Barnes has obtained satisfactory results in his experiments conducted at Narwala on the reclamation of alkali soils. The process consisted in successive operations of deep cultivation and provision of mole drains followed by washing with irrigation water.

Bacteriology of alkali soils.—Excessive washing of alkali soils was found by Barnes to result in the soil loosing its nitrifying power ; the nitrifying organism being still present but in an inactive condition. Nitrogen fixing bacteria were not normally found at lower than 6 inch depth while both ammonifying and nitrifying organisms were present at a depth of 9 ft. from the surface, this being the lowest depth to which the investigation was carried.

Soil gases.—Leather has directly measured the volume of gas in Pusa soil under different conditions and determined the amounts of the various constituents (including argon, hydrogen and methane). The volume of condensed gas in this soil is very small. Soil in the neighbourhood of roots of plants yielded gases containing a high proportion of carbon dioxide, a low proportion of oxygen and some hydrogen. The argon determination demonstrates with certainty that, in the case of gas from rice land soils, most of the nitrogen is derived from the soil and manure. As regards the influence of nitrification on the oxygen of the soil gas, Leather comes to the conclusion that the diffusion of gases in soils is sufficiently rapid to prevent a deficiency of oxygen.

Harrison and Aiyar have continued their study of the gases of swamp rice soils and have isolated a hydrogen-oxidizing bacterium from these soils.

The same authors have also investigated the source of the nitrogen gas found in these soils and its bearing on paddy manurial problems. This nitrogen is derived from two distinct sources, namely, (*a*) from the decomposable organic matter of the soil or of the green manure used, and (*b*) from a certain proportion of the roots of the crop which die and subsequently decompose. Under normal conditions in uncropped soils the nitrogen gas produced escapes from the soil into air at a fairly uniform rate. On the other hand that produced in cropped soils does not escape in any quantity until about the time when the plant is running up for flowering. At this stage a very marked escape of gas occurs which continues up to and past harvest time.

This irregularity in the escape of the soil gases from cropped paddy soils is a purely physical phenomenon, and is caused by the roots of the crop forming, in conjunction with fine soil, a surface layer which resists the passage of the gases. The action of the roots in retarding the escape of the soil gases conserves the methane and thus makes it available for the later stages of growth when the plant is more mature and the demand for root æration greater.

The authors conclude that the nitrogen of green manures has little actual manurial value, and that such manures owe the efficiency mainly to their indirect action on the soil and by increasing root æration. The best cropping results seem to be attained when the use of green manures goes hand in hand with that of artificial manures.

WATERS.

Waters in the Trap area.—Mann is making an extensive study of the underground waters of the Trap area of Western India and more particularly of those which are of use for agricultural purposes. In this region the water is almost always what may be termed " fissure waters " that is to say, it is not a generalised subsoil water which is tapped but water flowing in definite fissures in a definite direction. As a consequence of this, at least forty per cent. of wells under normal condition are failures even in selected sites. The automatic waterfinder can, however, be used with advantage, in locating streams of water which can be tapped either by well-digging or by boring.

As to the conditions which lead to soft irrigation water being injurious to a black cotton soil, Mann has found that if chlorides or sulphates in large quantity accompany alkaline bi-carbonates, the water is relatively innocuous; but if the bi-carbonates of the alkalis are present in quantity greater than the chlorides, then it is injurious. The harmful effect in the latter instance is due to the deflocculation of the colloid clay material.

A very interesting point brought out in the course of the present investigation was the fact that in the case of wells in parts of Gujerat (*e.g.*, near Surat) when there is a long drought or when too great a proportion of the water available in a well is utilized, the well is liable to be rendered permanently useless due to infiltration of sea water.

Mann and Paranjpe have found that the salt content of the waters of the intermittent springs at Rajapur in the Bombay Presidency is that of a typical trap water. They have further investigated the waters of the hot springs of the Ratnagiri district including the one at Rajapur. The composition of these is remarkably constant. Over forty per cent. of the solid matter in all the waters (except that at Rajapur) is chloride.

These investigations are expected to throw a considerable light on the study of the decomposition of the deep seated rocks of the trap area.

Waters from tube wells.—Water obtained from tube wells at Dehra Ghazi Khan has been found by Barnes to contain a considerable quantity of iron in a reduced condition which on æration of the waters leads to the formation of a deposit at hydrated oxide of iron. This excess of iron in solution results in the growth of crenothrix on the water pipes.

Lyallpur water supply.—A thorough study both chemical and bacteriological of Lyallpur municipal water supply has been made by Barnes during the last year.

The rise of water level in Lower Chenab Canal Colony.—Barnes has also been measuring the amount of water lost by evaporation from the subsoil water table.

MANURES.

Artificial manures.—Mann and Paranjpe have published the result of a large number of experiments on the use of artificial manures for many of the staple crops of Western India. These included five field crops (tobacco, potatoes, wheat, cotton and sugarcane) and four garden crops (chillies, onions, lucerne and plantains).

The results obtained by artificial manures can often, if not always, be equally obtained by the use of other materials like oil cakes, fish and bones. The advantage of the artificial manures lies in the fact that results can often be produced more speedily and more cheaply by their use, and that, more especially in the case of superphosphate and potash fertilizers, they can be used to supplement the deficiencies of other manures when dealing with certain soils and certain crops.

Attention is drawn to the fact that in most cases artificial manures can only be profitably used where the rainfall is reliable or where there is irrigation.

Recommendations are made as to the composition of mixtures of artificial manures suitable for use in different regions of the Presidency for the various crops.

FEEDING STUFFS.

Rice.—Sen has found that the composition of the rices of Bihar and Orissa is in the main similar to that of other rices analysed by previous workers.

When expressed as percentages of the dry matter, the sum of the albuminoids and soluble carbohydrates in husked rice generally lies between 94 and 95. There is relatively more phosphoric acid and potash in the bran than in the inner material. The nitrogen is more uniformly distributed. The greater acceptability of milled rice is therefore attained at considerable loss of mineral substances.

Warth is continuing his enquiry into the effect of environment on development and quality of paddy. Experiments to determine the factors affecting fragility of rice grains (with reference to losses in milling) have yielded some preliminary results.

Sen has studied the assimilation of nutrients by the rice plant. *Kalamdan* paddy was grown on an uniform plot of rice land at Sabour. In order to do away with the disturbing factors consequent on transplanting, the crop was allowed to grow to maturity in the same field where it was sown. Representative samples of plants were analysed at various stages of growth. The percentage of nitrogen exhibits a continuous decrease from the first to the last period of growth. There is a tendency for the nitrogenous matter to

press forward towards the top of the plant. The configuration of the curve of the content of phosphoric acid shows that the amount of this plant food available for the crop at Sabour was low throughout. The assimilation of nitrogen, phosphoric acid and potash by the plant is fairly complete by the time flowers appear.

The same author has also determined the feeding value of the different parts of the rice plant at various stages of growth.

Cooking of Red gram.—Viswanath, Row and Ayyangar have examined some factors affecting the cooking of red gram (*Cajanus indicus*). Dissolved salts, such as are found in natural waters, exert a marked influence on the time required for cooking. The rate of cooking may either be retarded or accelerated by the dissolved salts. The effect depends on the nature of the salt and is approximately proportional to the concentration. The rate of solution of the proteids appears to be the factor which mainly controls the rate of cooking.

Milk.—Leather has found that although the variation of freezing point among milks of Indian cattle is greater than has been found elsewhere, it forms a much more delicate test for added water than those hitherto employed.

Warth has made an extensive enquiry about the composition of Burmese cow's milk. An inquiry into the Mandalay milk supply has been nearly completed.

Clarified butter.—Barnes and Singh have determined the constants of oil of *poli* seeds (*Carthamus Oxyacantha*) which is used as an illuminant and also as an adulterant of *ghee* or clarified butter.

Date palm.—Annett is continuing his investigations on the date sugar industry.

The dark colour of palm *gur* is due to the palm juice containing potassium bicarbonate which acts on the glucose and lævulose in the juice during concentration with the production of dark bodies. Perfectly light coloured products are obtained if the juice is neutralised with acids before it is concentrated.

The use of lime in the collecting pots preserves the juice very efficiently. If this procedure is followed, even day juice can be boiled down to *gur* and thus about 20 per cent more sugar obtained than is at present yielded by the same number of trees.

Tests have been made to ascertain the amount of fuel used by the cultivators to make one maund of *gur*. Further data have been collected relating to the flow of juice from the trees.

Sugar beets.—Barnes has shown that suitable beet seed can be raised in the colder climate of Kashmir for use in the Punjab or North-Western Frontier Province and has demonstrated the suitability of the Kashmir climate for beet cultivation where the possibility of a beet sugar industry is very promising.

Sugarcane in the Punjab.—Barnes has also conducted manurial experiments on cane, the testing of cane varieties and an investigation on the effect of cold on the sugar content of the juice of different varieties. Better canes are to be found in the Southern Punjab (*e.g., Karnal District*) than at Gurdaspur.

Sugarcane in the United Provinces.—Clarke is continuing his selection of improved varieties of sugarcane in the United Provinces. He lays special stress on the importance of earthing up the cane before the rains. Heavy crops of improved canes grown on the light soils of Rohilkhand that are not earthed up almost invariably fall down during the heavy rains and high winds that prevail during the monsoon in the sub-montane tracts. The quantity and particularly the quality of the *rab* and *gur* are thus badly affected.

Two varieties of improved canes were grown and the crops tested on the factory scale. The results obtained confirm numerous tests that have been made on a smaller scale at the Research Station at Shahjahanpur.

Juar.—Taylor and Ghosh found that in a field of Juar where as many as three cases of cattle poisoning had taken place, half a grain of prussic acid was present per lb. of the crops. The process of storing the green fodder in a silo considerably minimises the danger, by breaking up the cyanogenetic glucoside, and makes the silage a safe food.

Burma beans.—Warth is studying the effect of environment on prussic acid content of Burma beans. Line cultures containing very high and very low proportions of prussic acid have been separated. Definite conclusions regarding the possibility of maintaining field crops almost free of the poison are expected soon.

Composition of South Indian Food stuffs and fodder.—Harrison has analysed a large number of South Indian Feeding stuffs and is going to publish the results soon.

MISCELLANEOUS.

Leaves of Betel vine (*Piper betle*).—Mann and Patwardhan have found that it is the quantity, and also the character, of the essential oil which seems most largely to determine the value of any sample of betel-vine leaf for chewing. The essential oil consists of a mixture of certain phenols and certain terpene-like constituents. Of the phenols eugenol is always the chief constituent in Indian oils, mixed with a small quantity of betel-phenol. Chavicol has not been found in Indian oils. As regards taste the best essential oil is that which contains the largest proportion of phenols. Leaves containing more terpene are very pungent but are looked upon as very coarse. Bleaching not only increases the amount of essential oil in the leaf but increases the proportion of phenols in the essential oil.

Bleaching has to be carried out in the dark and can be most successfully accomplished at a temperature higher than is usual in the commercial process.

Mineral constituents of Cotton Lint.—Barnes has found that the inorganic constituents of cotton fibre are more variable than has hitherto been supposed. The ash of pure cotton lint may be from 1·18 to 3·99 per cent. (on dried lint). He lays stress on the composition of the ash (and particularly on the insoluble portion of this) as likely to be of importance to the dyer and spinner in affecting the behaviour of the cotton towards the chemicals used in dyeing. He did not find any evidence of the supposed practice of salting cotton to increase its water-holding capacity.

Organic phosphoric acid of wheat.—Clarke has obtained a mixture of complex calcium and magnesium salts of organic phosphoric acid from wheat by extraction with dilute hydrochloric acid. It is similar to phytin obtained by this author from mustard and is decomposed by sulphuric acid into inositol and phosphoric acid.

Stimulating action of copper sulphate.—Harrison has found that small amounts of copper sulphate act as a crop stimulant when introduced into the irrigation water.

Calotropis gigantea.—Hill and Sarkar have examined the composition of the root bark of *Calotropis gigantea* and have found a bitter principle giving the usual reactions for alkaloids.

Indian Hyoscyamus.—Barnes have analysed a sample of Indian Hyoscyamus grown in the Punjab where large quantities of the plant occur in the wild state along the river sides. The assay showed the dried plant to contain the very high amount of 0·827 % of mydriatic alkaloids. Manufacturing chemists can thus obtain an adequate supply of the raw material for the preparation of hyoscyamine from Northern India.

Insects attacking wheat.—Barnes and Grove have shown that wheat is not a hygroscopic substance and that it cannot take up much more moisture than it contains at harvest time—the time when wheat is at its driest. Experimental evidence shows that moisture in the wheat is not an important factor in insect attack.

The process of respiration is the result of enzymic activity under the control of the cell. The authors have succeeded in proving this by separating the particular type of oxidation which takes place in the larvæ of *Attagenus undulatus,* Motsch. from the living processes.

The asphyxiating effects of carbonic acid, hydrogen and nitrogen gases on the three insects *Calandra oryzæ*, Linn., *Rhizopertha dominica,* Fb. and *A. undulatus* have been determined. The lighter or less dense the gas, the shorter the time to kill the insects. Increase in temperature also brings about a shortening of the lethal period. It is pointed out that respiration being shown to be an enzymic action the ordinary chemical laws governing the rate of chemical reaction will apply, increasing the velocity of reaction with increasing temperature.

It is concluded that no inert gas such as carbonic acid can be economically used as an asphyxiating agent for these insects, owing to their ability to enter

on a "hibernating" stage when atmospheric oxygen fails them and also because carbonic acid itself materially affects the germinating power of wheat.

Sulphur dioxide gas cannot also be used on account of its injurious effect on the vitality of the grain and destruction of the flour for breadmaking purposes.

Recourse must, therefore, be had to chemical deterrents or mechanical methods of treatment. The former procedure, however, appeared to present difficulties in grain which would afterwards be used for food. The authors recommend the use of an air blast cleaner which combine the advantages of shifting with those of a density separation.

Sugarcane.—The presence of aconitic acid in sugarcane juice has been confirmed by Taylor.

List of Publications.

BARNES, J. H. . .	The mineral constituents of cotton lint.
" " . .	"Indian Hyoscyamus." (*Agri. Jour. India, 1916, xi, 85.*)
BARNES, J. H. and SINGH, A.	Poli-oil—a new adulterant of *ghee*. (*Analyst, March 1916, xli, 72.*)
BARNES, J. H. and GROVE, A. J.	The insects attacking stored wheat in the Punjab and the methods of combating them (including a chapter on the chemistry of respiration). (*Mem. Dept. Agri. India, Chem. Ser., iv, No. 6.*)
CLARKE, G. . .	Improved sugarcane in the United Provinces. (*Agri. Jour. India, 1916, xi, 243.*)
" . . .	The organic phosphoric acid of wheat. (*Trans. Chem. Soc. (1915), cvii, 360.*)
HARRISON, W. H. and AIYAR, P. A. S.	The Gases of Swamp Rice Soils, Part III. (*Memoir Dept. Agri., India, Chem. Ser., iv, No. 4.*)
" . .	The Gases of Swamp Rice Soils Part IV—The source of the gaseous soil nitrogen. (*Memoir Dept. Agri. India, Chem. Ser., v, No. 1.*)
HARRISON, W. H. and VISWANATH, B.	A Soil survey of the Guntur Delta. (*Dept. Agri. Madras, Bul. 70.*)
HILL, E. G. and SARKAR, A. P.	The root bark of *Calatropis gigantea*. (*Trans. Chem. Soc. (1915), cvii, 1437.*)
LEATHER, J. W. .	Soil Gases. (*Memoir Dept. Agri. India, Chem. Ser., iv, No. 3.*)
" . .	The detection of added water in milk in India. (*Agri. Res. Inst., Pusa, Bul. 57.*)

MANN, H. H. . . . Experiments with the Automatic Water Finder in the Trap Region in Western India. (*Dept. Agri. Bombay, Bull. 72.*)

" . . . Well Waters from the Trap Area of Western India. (*Dept. Agri. Bombay, Bull. 74.*)

MANN, H. H. & PARANJPE, S. R. Intermittent springs at Rajapur. (*Jour. Bombay Roy. As. Soc., 1916, xxiv.*)

" . . . Hot springs of the Ratnagiri District. (*Jour. Bombay Roy. As. Soc., 1916, xxiv.*)

" . . . Artificial Manures; Experiments on their value for crops in Western India. (*Dept. Agri. Bombay, Bull. 76.*)

MANN, H. H. & PATWARDHAN, V. G. Studies in the chemistry and physiology of the leaves of Betel Vine (*Piper betle*) and of the commercial bleaching of betel-vine leaves; Part II. (*Memoir Dept. Agri. India, Chem. Ser., iv, No. 7.*)

SEN, J. . . . A Preliminary Chemical Study of the Rices of Bihar and Orissa. (*Agri. Res. Inst., Pusa, Bull. 62.*)

" . . . A Study in the nutrition of the Rice Plant. (*Agri. Res. Inst. Pusa, Bull. 65.*)

TAYLOR, C. S. & GHOSH, M. N. Cattle poisoning by *Juar* and its prevention. (*Dept. Agri., Bihar and Orissa*, Half-yearly Journal, iii, No. 2, p. 7.)

VISWANATH, B., ROW T. L. & AYYANGAR, P. A. R. Some factors affecting the cooking of Dholl (*Cajanus indicus*). (*Memoir Dept. Agri. India, Chem. Ser., iv, No. 5.*)

WARTH, F. J. . . Note on the soil of the Experimental Farms. (*Dept. Agri. Burma, Bull. 13.*)

PART II.—FOREST CHEMISTRY.

BY

PURAN SINGH, F.C.S.,

Chemical Adviser to Forest Research Institute.

The following is a brief account of the more important work carried out by the Chemical Department of the Forest Research Institute during the year 1915-1916 :—

ESSENTIAL OILS AND OLEO-RESINS.

Boswellia serrata gum-resin and its products.—After prolonged research, the best method for the manufacture of the Boswellia products

has been arrived at, which has in it all the elements of a process workable on a commercial scale.

The three products *i.e.* (1) oil of turpentine, (2) Boswellia rosin and (3) Boswellia gum, obtained by this process, were submitted to different firms and to the Imperial Institute, London, for commercial valuation. The turpentine oil is a first grade pinene oil, equal in quality to the French and American oils, though it has a characteristic aroma of its own. Messrs. Turner Morrison & Co., of Calcutta, pointed out that Boswellia turpentine, redistilled, had the disadvantage of having too low a flash point *viz.*, 86°Fah. The crude oil has a flash point of 90°Fah. This comes quite near the American oil. It seems unnecessary, therefore, to rectify the oil, as the first distillation gives quite a good product. The Boswellia rosin has been pronounced to be as good as the pine rosin for all industrial purposes for which the latter is used, except for saponification. This is due to the fact that Boswellia resin differs from pine resin in its chemical composition. The gum, as it comes out of the Laboratory, contains about 8 per cent. of ether-soluble resin and about 3 per cent. of ash.

It was sent to the Elgin Mills, Cawnpore, who reported that it could be employed as a substitute for farina in sizing textile materials. One of the Bombay firms referred to gave a similar opinion, though another Bombay firm pronounced it to be unsuitable for sizing purposes. The latter however, possibly, did not give it a fair trial. It is a new material and the process of preparing it for use is slightly different. The report from the Imperial Institute is unsatisfactory, as they only give the analysis of the gum and do not appear to have referred it for trial to any commercial firm. According to this report, the gum has about 21 per cent. of solubles in alcohol (95 per cent.) and 3 per cent. of ash. Unless large samples of the article are put on the market and some firm gets interested in pushing its sale, it is not possible to get any definite commercial opinion about the gum. It is probable that the gum produced on a commercial scale in a better type of Extraction Plant would be of better quality than that which it has been possible to extract in a small laboratory plant worked under conditions necessarily differing to some extent from those obtaining on an industrial scale.

Distillation of Eucalyptus globulus oil in the Nilgiris.—As a result of a winter tour carried out by the Chemical Adviser in the Nilgiris, a Note embodying a complete study of the Eucalyptus Oil Distillation Industry in this locality is now in the press. It has been shown that no expansion of this industry is possible without adequate arrangements for a larger leafsupply. It has been suggested that new plantations be started solely for the supply of leaf and that the leaf resulting from coppice shoots, one year old, could also be used. Various recommendations have been made with a view to improving the present methods of distillation and filtration as practised by the Nilgiri distillers. It has been shown that the Nilgiri Eucalyptus oil is free from the objectionable aldehydes which induce cough-

ing. Redistillation of the oil is therefore unnecessary provided the primary distillation is properly carried out.

Wintergreen Oil from Gaultheria fragrantissima of Assam and the Nilgiris.—An exhaustive note has been submitted on the results of experiments carried out with parcels of leaves of *Gaultheria fragrantissima* obtained both from the Nilgiris and from Assam. The latter gave very much better results than the former. This is the first occasion on which experiments with Gaultheria have been carried out on a commercial scale in India. From the oil of wintergreen thus distilled *natural* Salicylic acid, *natural* sodium salicylate and acetyl salicylic acid have been prepared, samples of which have been sent for commercial valuation and favourable reports received. It has been shown that the industry would well repay attention, if Gaultheria were cultivated on a large scale.

The Wild Geranium of the Nilgiris.—In addition to the oils already referred to, the Chemical Adviser distilled quantities of Wild Geranium growing in the Nilgiris and the resulting oil has been shown to be equal to the pure Geranium oils of the European market. A note on the subject is in the press.

The oil and resin of Frenella rhomboidea (Callitris rhomboidea, R. Br.) planted in the Nilgiris.—The resin obtained from the cones of Frenella rhomboidea, which is similar to Sandarach, is under examination. The oil distilled at Ootacamund from the leaves of this tree has been examined and its constants determined. The commercial report on the sample of oil sent to London through Messrs. Smith Stanistreet & Co., is being awaited. The report obtained by the Forest Economist from a Soap-making Firm in Bombay, was favourable, frenella-perfumed soaps having been prepared. The tree, however, is not available in large quantities and it deserves to be cultivated more extensively in the Nilgiris.

The oil of Blumea Malcolmii.—The distillation of *Blumea Malcolmii* leaves on a large scale was undertaken by the writer at the request of the Divisional Forest Officer, Belgaum, in the Belgaum Division. About a ton of the raw material was distilled. The oil has never been distilled before and is under study. The preliminary work shows that its main constituent is Pulegone, the Ketone occurring in the Pennyroyal oil of Europe. This has yet to be confirmed.

The constants of the steam-distilled Motiya Rosha Oil.—The constants of the steam-distilled Motiya Rosha Oil and the same redistilled have been worked out for comparison with figures previously recorded. They were in fair agreement.

TANNINS.

Burma Myrabolans as a tanning material.—The Burma myrabolans, believed to be the fruits of *Terminalia Chebula* and received from different localities, have been examined. It has been shown that the composition

of the Burma myrabolans as a tanning material is different from that of the Indian myrabolans, in as much as the former contain half the amount of tannin and double the amount of non-tannins as compared with the latter. The tan liquors made from Burma myrabolans are moreover more deeply coloured, but it has been shown by actual tan-yard experiments that their tanning properties are similar to those of the Indian myrabolans. Suggestions for the preparation of Burma myrabolans for the market have been made. A note on the subject is in the press.

A study of the fruits of Zizyphus xylopyrus and the Wattle Barks of the Nilgiris as tanning materials.—The fruits of *Zizyphus xylopyrus* were examined to determine the best season for their collection and large scale tan-yard experiments were carried out, in co-operation with the Allahabad Tannery, in order to ascertain their suitability for leather tanning. They have given good leather but the penetration of the tan liquor is about twice as slow as in the case of Babul bark. A note on the subject is under preparation. The analysis of the wattle barks of different ages from exotic Acacias, planted in the Nilgiris, has almost been completed. A note on the subject is under preparation.

Prosopis glandulosa.—The wood of this tree was examined with a view to making cutch from it. The preliminary examination of the wood gave :—

	Per cent.
Moisture	24·00
Total solids	14·48
Non-tannin	6·60
Tannin	7·88
Alcoholic extract	12·38
Catechin	absent.

From this composition, it is clear that the wood could be used for the manufacture of a sort of cutch but not of the edible *katha* of the Indian market. Consequently a sample of cutch was prepared and sent to the Forest Economist. Its analysis gave :—

	Per cent.
Moisture	14·88
Total solids	75·12
Non-tannin	34·72
Tannin	40·40

The cutch has been sent for commercial valuation. If it proves as good as the cutch used for dyeing purposes, it might be worth while to extend the plantations of Prosopis in the Punjab.

Rhus parviflora.—In addition to the leaves of *Rhus Cotinus*, the leaves of *Rhus parviflora* could also be used as Sumach. A sample of leaves

received from the Chief Conservator of Forests, United Provinces, gave the following results :—

	Per cent.
Moisture	9·90
Ash	6·75
Total solids	28·21
Soluble solids	27·57
Insolubles	0·64
Non-tannins	15·97
Tannin	11·60

It should make a very good auxiliary tanning material for admixture with *Sal* and *Sain* barks and with myrabolans.

MISCELLANEOUS.

Opium Alkaloids.—A sample of the Malwa opium received from the Gwalior Durbar for a commercial assay for morphine, narcotine and codeine gave the following results :—

			Calculated on dry material.	
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	10·84		..	
Ether Extract	26·10		29·23	
Waxy matter	18·50		20·75	
Narcotine Crude crystals	7·60	Total alkaloids 12·99	8·52	14·57
Pure morphine crystals	4·72		5·3	
Codeine	0·67		0·75	
Ash	4·51		5·06	
Total watery extract (hot), made by extracting opium dried at 100° C.	55·10		61·75	

Assay of the roots of Rubia cordifolia and Morinda citrifolia for Alizarine.—Owing to the scarcity of the synthetic dyes many enquiries were received relating to the possibility of utilising vegetable dyes as substitutes. A sample of the roots of *Rubia cordifolia*, received from a Bombay merchant, was assayed for the total dye content. It gave 3·20 per cent. of the total dye, consisting of alizarine and purpurine. The roots of *Morinda citrifolia*, received from Mr. T. Clear of West Kurnool, were poorer in dye content than the roots of *Rubia cordifolia*. They contained 9·30 per cent. moisture and 1·49 per cent. total dye of which 0·13 per cent. was purpurine. It was shown that it would not be possible to compete with synthetic dyes in normal times, and it is therefore inadvisable to put up an extraction plant for the manufacture of alizarine only, during the present crisis, unless one is

prepared to employ the same plant for some other purpose when normal pre-war conditions are restored.

Oil Cake from Butea frondosa.—A sample of the *Butea frondosa* oil cake received from the Patiala Forest Department was examined, with the following results :—

	Per cent.
Moisture	6·74
Fat	8·73
Albuminoids*	13·67
Carbohydrates	21·80
Pectous and Fibrous matter	42·45
Ash	6·61
	100·00
*Organic nitrogen	2·18

It could be used both either as a fodder and or as a manure.

Creosote Oils distilled in India.—A few samples of creosote oils, distilled out of coaltar in India, were examined as to their suitability for replacing the imported creosote oils in the sleeper treatment. As a result of various tests made, it was suggested that the oils were still too light for sleeper treating purposes and they should contain a greater proportion of high boiling constituents.

Mulberry Gur.—A sample of *Gur* made from Mulberry fruits, so abundant in the Changa Manga Mulberry plantations, was received from the Forest Economist for analysis and for suggestions as to its possible uses. It gave the following results :—

	Per cent.
Moisture	20·15
Insolubles (by difference)	0·90
Glucose	66·75
Cane Sugar	10·20
Ash	3·73

As such, it could only be employed as glucose in the manufacture of industrial alcohol. But with sugarcane *gur* so cheap in India, it would hardly be worthwhile to make mulberry *gur*, even as a secondary article of commerce. The whole question, however, depends mainly on the cost of the material thus produced, as compared with sugarcane *gur*.

Calorific value of wood of different ages and of charcoal of Eucalyptus globulus, grown in the Nilgiris.—At the request of the District Forest Officer, Nilgiris, the calorific values of the wood of *Eucalyptus globulus*, of different ages from 5 years to 53 years, were determined. The calorific value ranged between 6868 and 6957 British Thermal Units. Similarly the wood of *Acacia dealbata* gave 6863, *Acacia melanoxylon* 6876, the charcoal of *Eucalyptus globulus* 13,512, B.T.U's.

The Padauk Dye.—A sample of saw dust of Andaman Padauk was received for a report as to the dye contained in it. The dye in it was found to be the well known colouring matter called *Santal-red* which occurs in the Sanders wood, *Pterocarpus santalinus*. The colouring matter comes out with alcohol as a red resinous mass. The saw dust gives 21·67 per cent. of alcoholic extract and 9·62 per cent. of ether extract. This dye is used for dyeing wool. The alcoholic extract can be used as a dye, but being insoluble in water, a very small amount enters into solution in the dye-bath at one time and the process of dyeing is consequently extremely slow. Owing to the long boiling and to some specific action of the dye itself, it is stated that the wool invariably goes rotten when dyed with these insoluble reds. As such the Padauk dye has no economic prospectus.

Soils.—The study of soil chemistry, in collaboration with the Forest Botanist, was continued.

List of publications issued during the year or in the press at the close of the year.

GHOSE, T. P. . . Note on the Field Test for the Detection of parafin adulteration in Bees-Wax. (*Ind. For., April 1916.*)

SINGH, PURAN . . Note on the Effect of age on the Catechin-Content of the wood of *Acacia Catechu*. (*Ind. For., December 1915.*)

" " . . Note on the Differentiation of In and *Kanyin* species of *Dipterocarpus* timber of Burma. (*Ind. For., May 1916.*)

" " . . Note on the Constants of Indian Geranium oil (Motia). (*Ind. For. Rec., v., Pt. vii., June 1916.*)

" " . . Note on the Burma Myrabolans or Panga Fruits as a tanning material. (*Ind. For. Rec., In Press.*)

" " . . Note on the Eucalyptus Oil Industry in the Nilgiris. (*Ind. For. Rec., In Press.*)

" " . . Note on the Distillation of Geranium Oil (*Ind. For. Rec., In Press.*)

" " . . Note on the manufacture of Wintergreen Oil and Salicylic Acid in India. (*Ind. For. Rec., In Press.*)

ASTRONOMY.

BY

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Director-General of Observatories.

Solar physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikanal, the Director being Mr. J. Evershed and the Assistant Director Mr. T. Royds. The chief instruments are :—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is to take photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and so shall emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikanal spectroheliograph the collimating and camera lenses each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate ; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently ' reversed,' *i.e.*, is bright instead of dark indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called ' flocculi '—of calcium vapour

scattered about over the sun, and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

(*b*) An autocollimating spectroheliograph built in the observatory workshop. This is attached to the side of the Cambridge instrument and shares in the very perfect transverse movement of the latter. It is designed for photographing the sun's disk in the hydrogen line C. A large grating is used to obtain the highly dispersed spectrum which is necessary in photographing with this line.

(*c*) A high dispersion spectrograph mounted on piers in the spectroheliograph room. This is fitted with special arrangements for rotating the sun's image on the slit plate, and for accurate guiding during long exposures on sunspots or prominences. A special device has also been added for photographing simultaneously the spectrum of an electric arc on either side of a solar spectrum. A grating by Anderson with 5-inch ruling is usually employed.

(*d*) An 18-inch parabolic mirror (the property of the Director) is mounted in the spectroheliograph room immediately in front of the 12-inch photo-visual lens. It is used to form the solar image on the slit plate of the high dispersion spectrograph. The mounting is on rollers and the mirror can either be moved into position in front of the lens with its centre in the axis of the beam of light coming from the heliostat, or it can be pushed to one side so as not to obstruct the light incident on the lens during employment of the spectroheliograph and associated instruments.

(*e*) An 8-inch visual achromatic lens from the Maharajah Takhtasingji Observatory, Poona, temporarily mounted in the spectroheliograph room on a pier near the Foucault siderostat. It is used for forming a solar image on the spectrograph slit specially for sunspot work.

(*f*) A 6-inch equatorial refractor with large grating spectroscope attached is used for the study of sunspot and prominence spectra and for recording the prominences by visual methods. The equatorial mounting and the spectroscope are from the Maharajah Takhtasingji Observatory, Poona.

(*g*) A new spectroheliograph for photographing the sun on any scale up to 4½ inches to the diameter was partly constructed in the Observatory workshop, and afterwards erected and completed at Srinagar, Kashmir. A new feature in this instrument is

the provision of two sets of prism trains and a grating, which may be used alternatively in such a manner that the instrument may be immediately converted into a spectrograph of low dispersion for stellar spectra, or very high dispersion for sunspot spectra.

Routine Work.—Daily spectroheliographic records of the sun are obtained at Kodaikanal in calcium and hydrogen light, whilst similar records are obtained in Kashmir, mostly in the H line of calcium. In addition, the routine work at Kodaikanal includes visual examination of sunspots and faculae, sunspot spectra, and bright lines or displaced lines in spots and prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes bulletins and memoirs of the Observatory are issued. Of the former, 49 have appeared, while of the latter the first has been published, and the MS of the second is ready for the press.

Spectroscopic Investigations.—The research on the change of wave-length of the iron lines, in passing from the centre of the sun's disc to the limb, has been completed and published. It is found that the displacement of the lines at the centre of the disc towards red is not due to a circulation of the solar gases in a radial direction, but is probably part of a general displacement increasing from the centre towards the limb. It is also shown that the difference of shift between lines at the centre and at the limb is not due to a pressure effect. From the evidence obtained, there appears to be a general movement directed away from the Earth all over the sun's disc, affecting only the higher parts of the atmosphere at the centre, and both higher and lower layers at the limb.

Some investigations have been carried out which lead to the conclusion that any mutual influence of adjacent lines due to anomalous dispersion is inappreciable in the solar spectrum, and we consider that anomalous dispersion is ruled out as an effective agent in displacing solar lines.

A preliminary series of experiments has been made with the Kashmir spectroheliograph, used as a stellar spectrograph, for finding the best method of photographing the spectrum of Venus. If this could be photographed under sufficiently high dispersion, decisive evidence could be obtained confirming or otherwise the apparent general movement of recession from the Earth of the solar gases. The experiments have proved that with the existing apparatus the required spectra can be obtained, but means must be provided for control of the temperature of the prisms.

Photographs have been obtained for determining the displacements of the nickel and titanium lines at the centre of the sun's disc and at the limb, and the measurement of these is proceeding. Preliminary determinations appear to confirm the results obtained with the iron lines.

The displacements of the nickel lines at the negative pole of the electric arc have also been obtained for comparing with solar displacements, with

which they are closely related. General experiments on the displacements at the negative pole have shown that this is not strictly a pole effect, nor due to increased amplitude of the vibrating electrons, and density still remains as the most probable cause. The chief difficulty in the way of further progress is to find a means of controlling the density in the source of light.

A series of spot spectra showing radial motion effects has been measured, and the results show that the velocity may be very unequal on opposite sides of the penumbra of a spot at equal distances from the centre of radiation. It is also found that horizontal movements may occur in a direction at right angles to the radial motion, which are not of the nature of a rotation, or vortex movement, but seem to be irregular. One spot gave clear evidence of radial motion extending over the photosphere far outside the penumbral region. The detailed results of this investigation are now in the press.

List of Publications.

The following papers have been published since the last Report :—

ROYDS, T. . . . Summary of Prominence Observations for the First Half of the year 1915, (*Bulletin No. 47*).

ROYDS, T. . . . Anomalous Dispersion in the Sun, (*Bulletin No. 48*).

EVERSHED, J. AND ROYDS, T. On the Change of Wave-Length in the Iron Lines in passing from the centre of the Sun's disc to the limb, (*Bulletin No. 49*).

ROYDS, T. . . . Summary of Prominence Observations for the Second Half of the year 1915, (*Bulletin No. 50*).

METEOROLOGY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Upper Air Examination.—The work with pilot balloons observed by theodolites was continued in North India at Agra, Simla and Kojak, and for South India at Bangalore, where the work is in the hands of the Meteorological Officer of the Mysore State and has been carried out with admirable zeal and accuracy. The trajectories to standard scale of the paths of all balloons are charted for determination of normal and abnormal conditions of wind strength and direction at all heights reached, *i. e.*, up to 10 or 11 kilometers. The number of these records now available is sufficient to provide a useful basis for a preliminary estimate of normal conditions for the various seasons of the year: the figures have accordingly been put into convenient form, and their analysis is nearly completed for publication.

In addition, pilot balloons were used for a short period at Nagpur; and balloons carrying instruments were sent up at Poona during the monsoon of 1915 and at Agra from June 1915 onwards continuously. A large proportion of these were found and returned, and those with good records afford information as to the temperature gradients and humidities at all heights reached.

The examination of past cloud records at representative stations in India for the period 1875 to 1914 has been completed for publication, and further observations at selected stations continue.

Statistical investigations.—In order to improve forecasting of the geographical distribution of rainfall the correlation co-efficients of the monsoon rainfall of all the rainfall divisions with the pressure in 16 divisions over India in May were worked out and proved negligible. The co-efficients of rainfall in the same areas with snowfall, with pressure at Mauritius and in south America, and with rainfall at Zanzibar, Seychelles and in the south of Ceylon in May were then examined and found to be appreciable. They showed that while most of the factors on which the forecasts of the total rainfall of India have hitherto been based exercise control over the field of the Arabian Sea current they have little or no effect on that of the Bay current; and further that rainfall in certain areas, such as Malabar and Lower Burma tends to vary in the direction opposite to that of India as a whole. By combining those areas which are sufficiently homogeneous an area 'India, main' is obtained for the monsoon rainfall of which the correlation co-efficient with factors available at the beginning of June is ·7, instead of ·6 the previous

co-efficient for the whole of India : and as this ' India main ' contains the United Provinces, the Punjab, the North-West Frontier Province, Sind, Rajputana, Bombay, Central India, the Central Provinces, Hyderabad, Mysore, the North Madras coast and Orissa it is sufficiently large to be of considerable practical value.

List of publications in the Memoirs of the Indian Meteorological Department :—

HARRISON, E. P. .	On the Calcutta standard barometer (xxi, Part xiii).
HARWOOD, W. A. .	A discussion of the anemographic observations recorded at Jubbulpore, Belgaum, Deesa and Karachi (xix, Parts v to viii).
JACOB, S. M. . .	Correlation of rainfall and the succeeding crops with special reference to the Punjab (*xxi, Part xiv*).
WALKER, GILBERT T. .	Correlation in seasonal variations of weather, IV, sunspots and rainfall (*xxi, Part x*).
WALKER, GILBERT T. .	Correlation in seasonal variations of weather, V, sunspots and temperature (*xxi, Part xi*).
WALKER, GILBERT T.	Correlation in seasonal variations of weather, VI, sunspots and pressure (*xxi, Part xii*).

TERRESTRIAL MAGNETISM

BY

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Director-General of Observatories.

Magnetic observatories.—Bombay (Alibag).—The Bombay Observatory, formerly maintained by the Local Government at Colaba, was moved to Alibag in consequence of the introduction of electric trams into the city. It is now directly under the Government of India, the Director being Dr. N. A. F. Moos. The chief instruments are a set of magnetographs of the Watson pattern, a set of sight reading instruments of Eschenhagen pattern, a Schulze earth-inductor, a Toepfer earth-inductor and ordinary magnetometers and dip-circles. There is also a large declinometer for eye observations, and the old Colaba horizontal force and vertical force magnetographs were in April 1912 transferred to Alibag for use as eye-reading instruments. There is thus a duplicate equipment both for absolute values and for variations.

The instruments have been in good order and under regular observation.

Dehra Dun, Kodaikanal and Toungoo.—These observatories were started as base stations in connection with the Magnetic Survey of India, and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip-circles, earth-inductors of the Schulze pattern have been set up at each place. Good results have been obtained throughout the year.

The mean values of the magnetic elements for 1915 at the observatories are as follows :—

Observatory.	North Lat. and East Long.	Declination.	Horizontal force.	Vertical force.	North dip.
			C. G. S.	C. G. S.	
Alibag	18° 38′ 72° 52′	E 0° 40′ 39″	·36870	·16688	24° 21′·1
Dehra Dun	30° 19′ 19″ 78° 3′ 19″	E 2° 15′·5	·33083	·32522	44° 30′·6
Kodaikanal	10° 13′ 50″ 77° 27′ 46″	W 1° 22′·3	·37614	·02817	4° 17′·0
Toungoo	16° 55′ 45″ 96° 27′ 3″	W 0° 3′·1	·39005	·16653	23° 7′·2

At Alibag these values are based on all days, but at the other three stations days of great disturbances are excluded. From the beginning of 1915 the present value of the moments of inertia and the revised values of the distribution co-efficients have been used to determine the values of the Horizontal Force; consequently the values in these tables cannot be compared with the values published in previous years. Values, revised as above, for 1914 are given below for comparison :—

—	1914.	
	Horizontal Force.	Vertical Force.
Dehra Dun	·33134	·32427
Kodaikanal	·37604	·02753
Toungoo	·38965	·16621

Magnetic Survey.—Field work 1915-16.—Since the repeat stations of the Magnetic Survey will be visited for magnetic observations at intervals of 5 years only, no field observations were taken during the year. It was however necessary for a detachment to proceed to Delhi to select a suitable site for a new station as the Bela land, on which the old site was situated, was being dug up under a scheme for grading the bank of the Jumna River. Comparative observations were taken by two observers at both the old and new sites, before the former was destroyed, to ensure a continuity of record for the determination of reliable secular change values for the locality.

Transfer of the Kodaikanal Observatory.—It has been deemed advisable to place the Kodaikanal Observatory under the control of the Meteorological Department for a better supervision of the work of the observatory than is possible at so great a distance from the Survey Head Quarters at Dehra Dun. Accordingly, with the sanction of the Government of India, the Magnetic Observatory and the observatory staff were transferred to the Meteorological Department on the 1st August 1916. The Director of the Kodaikanal Observatory will continue to send the periodical returns of magnetic observations as usual, in original and duplicate, to the officer in charge of No. 18 Party for the computation of the reduction of the observations and for record.

Reduction of the observations to epoch.—The final reductions of the magnetic observations to the selected epoch have been proceeded with throughout the year and are making good progress. The reduction of the declinations at all field stations to that epoch is nearing completion and will, it is expected, be ready for publication by the end of the year. It is proposed to issue with the reductions, tables of secular change, descriptions of all repeat

and field stations, and an isogonic chart. The value of the declination for any year other than the selected epoch may be obtained with the aid of the secular change tables and the chart. It will be necessary however to revise and extend these tables from time to time, as additional data derived from future observations at repeat stations become available. Since the secular change has not altered more than a minute in the last 10 years it would appear that no very large change is likely to occur in the next few years, and the tables can be used for all practical purposes until they are revised in 1919-20 when observations will be taken again at repeat stations.

GEOLOGY.

BY

H. H. HAYDEN, C.I.E., F.R.S.,

Director, Geological Survey of India.

CONTENTS.

PUBLICATIONS.

1. The publications issued by the Geological Survey of India during the year under review comprise two volumes of *Records* and one memoir of *Palæontologia Indica.*

LIBRARY.

2. The additions to the Geological Survey library during the year 1915 amounted to 2,523 volumes, of which 820 were acquired by purchase and 1,703 by presentation and Exchange.

MUSEUM.

3. **Meteorites.**—Only one meteorite fall was recorded in 1915. This occurred on the 19th of January 1915 at Visuni village, Umarkot Taluka, district Thar and Parkar, in Sind. The specimen, which was forwarded by the Collector of Thar and Parkar, is an almost complete aerolite, covered with crust except at one corner. The meteorite weighed 594 gms. Mr. H.

Walker has undertaken the description and is preparing a paper for publication in the *Records* of the Geological Survey. He determines it as a crystalline spherical chondrite (cck).

4. Eight fragments of meteorites were obtained by exchange from the United States National Museums, Washington. These are :—Hendersonville (116·8 gms.), Modoc (37 gms.), Long Island (52 gms.), Holbrock (114·7 gms.), Cullison (48 gms.), Crab Orchard (40 gms.), Williamstown (132·5 gms.), Perryville (98·2 gms.). The first six of these are stones, the last two irons. Three fragments were received by exchange from the South African Museum, Cape Town ; these are :—St. Marks (83·1 gms.), Jackalsfontein (54·2 gms.), and Matatiela (78·8 gms.). The first two are stones, the last an iron. Nine fragments were presented by the Trustees of the British Museum, *viz.*, Crumlin (38·7 gms.), Oshima (233·1 gms.), Zomba (27·9 gms.), Eli Elwah (75 gms.), Uwet (254·8 gms.), Barranca Blanca (49 gms.), Mount Hicks (64 gms.), Pan de Azucar (92 gms.), Cowra (29·5 gms.). The first four are stones, the last five, irons.

5. During the year fragments of the following Indian meteorites were despatched to other Museums :—

(1) to the Superintendent of the Government Museum, Madras, as a donation, a piece of the Kuttipuram meteorite, weighing 63 gms. ;

(2) to the Keeper of Minerals, British Museum, as a donation, pieces of the following falls :—

Bholghati (28·6 gms.), Mirzapur (208·8 gms.), Lakangaon (93·8 gms.), Shupiyan (65·9 gms.) ;

(3) to the Director, South African Museum, Cape Town, in exchange, pieces of the following :—

Karkh (two chips, 16·9 gms.), Dokachi (70·9 gms.), Khohar (83·1 gms.)·

6. **Donations Museums, etc.**—During the year various rock, mineral and fossil specimens were given either in exchange or as donations to the following museums, educational institutions and teachers :—

(1) Redpath Museum, Montreal, Canada ;

(2) Agricultural College, Nagpur ;

(3) Hooghly Training School, Hooghly ;

(4) Field Museum of Natural History, Chicago ;

(5) David Hare Training College, Calcutta ;

(6) Prof. T. W. Edgeworth David, Professor of Geology, Sidney University ;

(7) Miss Burnett Hirst, 11 City Road, Allahabad ;

(8) Prof. A. Lacroix, Musee d'Histoire Naturelle, Paris ;

(9) St. Patrick's Catholic Church School, Cawnpore;

(10) Diocesan College, Elgin Road, Calcutta.

7. **Additions and exchanges.**—Of the additions of foreign specimens to the Museum during 1915, the most important is a collection of igneous rocks from Skye and Glenelg in Inverness-shire, presented by Dr. Fermor. The collection is illustrative of the various types dealt with by Prof. Harker in his work upon the Igneous Rocks of Skye, and includes various kinds of basalt, rhyolite, peridotite, gabbro, granite, granophyre, Cambrian marble, marscoite, picrite and various specimens from the Lewisian and Torridonian systems and Moine schists.

A fine collection of specimens from the Stassfurt salt mines in Germany was received from Dr. W. A. K. Christie. This includes samples of kainite, carnallite, kieserite, picromerite polyhalite, hartsalz, sylvine and boracite.

Amongst minor additions of foreign specimens may be mentioned specimens of benitoite and of lithiophorite acquired by exchange from Mr. W. A. Roebling, United States of America, and also some gold nuggets from the Klondyke region, presented by Dr. L. L. Fermor.

A collection of English Tertiary fossils was received from Mr. F. R. Cowper Reed.

Amongst the many Indian specimens acquired by donation may be mentioned the following:—

(1) jamesonite from Shogot, Lutko Valley, Chitral, presented by Mr. Shiv Raj;

(2) wolfram from Degana, Marwar State, Rajputana, presented by Mr. H. A. Pearson;

(3) vein quartz carrying native gold from Kundru Kocha, Singhbhum, presented by the Dhalbhum Gold and Minerals Prospecting Co., Ltd.;

(4) molybdenite from the Godavari district, presented by the Executive Engineer, Godavari, Northern Division;

(5) apatite-magnetite rock from a mine near Ghatsila railway station, B. N. Railway, presented by Mr. P. E. Billinghurst.

MINERALOGY AND PETROLOGY.

8. **Blanfordite.**—Although blanfordite, the manganiferous pyroxene with striking pleochroism in tints of blue, carmine, and lilac, was first collected some twelve years ago, it has not hitherto been possible to subject it to chemical analysis on account of the lack of material of suitable purity and freshness. But, as mentioned in paragraph 9, Dr. Fermor has at last succeeded in obtaining from a pegmatite at the Kachi Dhana manganese mine in the Chhindwara district material suitable for this purpose. The analysis was undertaken by Mr. A. K. Banerji, Assistant Curator, on material separated

by means of Sonstadt's solution and carefully picked under the microscope. The specific gravity of the material analysed was 3·50 and the result obtained was as follows :—

	Per cent.
SiO_2	52·18
TiO_2	*nil*
Fe_2O_3	20·26
FeO	*nil*
Al_2O_3	5·89
MnO	3·60
CaO	4·37
MgO	3·25
K_2O	*nil.*
Na_2O	10·12
	99·57

Dr. Fermor finds that this analysis corresponds to a mixture of the mole cules of the pyroxene group in the following proportions :—

		Per cent.
Acmite—$Na_2O. Fe_2O_3. 4SiO_2$		58·72
Jadeite—$Na_2O. Al_2O_3. 4SiO_2$		14·78
$MgO. Al_2O_3. SiO_2$	4·50	26·01
$MnO. SiO_2$	6·66	
$CaO. SiO_2$	9·08	
$MgO. SiO_2$	5·97	
Surplus SiO_2		0·16
		99·67

The last four silicates may be regarded as forming a mangan-augite with 13·84 % of MnO. The striking pleochroism of the blanfordite may be due to the association of the soda of the acmite molecule with the MnO of the mangan-augite. It should be noticed that the original locality for blanfordite is Kacharwahi in the Nagpur district, and that it does not follow that the composition of the mineral from this locality will prove to be exactly the same as that of the Kachi Dhana mineral. Indeed, variations in the intensity of the colouration of the specimens from different localities suggest that the mineral varies somewhat in composition from place to place.

9. **Petrology of manganese ores of the Central Provinces.**—During his work in the Sausar tahsil Dr. Fermor revisited three of the manganese-ore deposits described in his memoir on the subject, namely Bhurakam (Ghoti), Kachi Dhana and Sitapar. Each of these yielded further interesting information. The Bhurakam deposit consists apparently of a series of thin parallel bands from 3 to 5 feet thick. But that the deposit is really a single band

folded repeatedly into an isoclinorium is shown by the presence on one side of the ore-band of a very fine-grained granulitic rock rich in spessartite and epidote, the latter being sometimes a mangan-epidote, suggesting withamite. The ore-band is composed partly of gonditic rocks and partly of manganese-ore of secondary origin formed by the alteration and replacement of spessartite and by replacement of intrusive pegmatitic rocks, often rich in spessartite. The gondite is itself often felspathic, and as the ore-band and associated granulite are completely enclosed in biotite-gneiss one would hesitate on the evidence of this locality alone to ascribe a sedimentary origin to the manganese band. But since, judging from evidence provided by other localities, this sedimentary origin is undoubted, it is necessary to suppose that the original character has been obscured mineralogically by hybridisation due to the addition of igneous material. This deposit serves, therefore, as a good example of the way in which a thin band of sedimentary rock may be folded in with igneous rocks, suffer serious mineralogical modification owing to the influence of the latter, and yet retain its physical identity as a stratum.

10. Kachi Dhana showed a fine example of intrusion of manganese-ore by pegmatite with inclusion of blocks of the ore in the pegmatite, proving as at Gowari Warhona,[1] that this type of manganese-ore was in existence before the pegmatite was intruded, and adding this deposit to the list of those that may continue as far as the manganiferous rocks descend. Considerable quantities of blanfordite were obtained from some of these pegmatites, a portion of the material being fresh enough for analysis.

11. The Sitapara quarry was revisited in order to record progress and to collect a further supply of the minerals hollandite, fermorite and sitaparite. The original outcrop showed ore composed of the above minerals, with some braunite, the mineral assemblage being unique. The quarry, which shows that the deposit forms a hill buried in alluvium, had, in February 1915, reached a depth of 60 feet. It was found that ore of the above type had given place to a more normal type composed largely of braunite similar to that of Kachi Dhana and many other deposits in the Central Provinces, hollanditic ore being obtainable *in situ* only in one corner of the pit; but hollanditic ore is the predominant type in the talus-ore lying on the slope of the buried hill. It thus becomes evident that the hollanditic ore is a surface modification of the normal type of ore, although the source of the strontium contained in the fermorite is still unknown. It is probably a case of the surface concentration of constituents that were always present in minute quantities in the primary ores (*e.g.*, arsenic, another constituent of fermorite). That the braunitic ore now exposed must be regarded as a primary ore of Archæan age is shown by the fact that this particular type of ore and not the hollanditic type, has been invaded by great masses of pegmatite, which now enclose large blocks of the braunitic ore.

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[1] Records, Geol. Surv. India, Vol. XLI, p. 5.

12. It is thus seen that Gowari Warhona, Kachi Dhana and Sitapar, all agree in proving that the main manganese-ore band was in existence before the pegmatite was intruded. The clear evidence that the special type of ore characterising the original outcrop at Sitapar was a secondary surface modification points to the possibility of such changes, though evidently to a less marked degree, in other deposits in the Central Provinces. Thus Dr. Fermor records that the Balaghat deposits shows abundant evidence of surface modification, although there is not any marked mineralogical change. It will not, however, be surprising if the finely granular hollanditic ore of this deposit comes to an end by the time water-level is reached, which will probably not be for years as the deposit is in a hill. It is interesting to note that at Balaghat there is a slow but gradual decrease in the manganese content of the ores with increasing depth of working. This may mean that the formation of the hollandite was accompanied by a slight enrichment. On this interpretation the decrease in manganese content would be expected to cease when the primary ore zone was reached. Fortunately in many of the manganese mines this primary ore seems to be up to the standard of first-grade ore.

PALÆONTOLOGY.

13. **Eocene mammals.**—Messrs. Pilgrim and Cotter have completed a joint paper embodying the stratigraphical and palæontological results of their study of the fossil mammals found by Mr. Cotter in the Pondaung Sandstone of Myaing in the Pakokku district in Burma. The mammalian remains include species of the *Anthracotheriidæ* and *Titanotheriidæ*, and have been referred partly to the genera *Anthracotherium* and *Metamynodon*, while two new genera, *Anthracohyus* and *Anthracokeryx*, have been established for certain species which cannot appropriately be referred to *Anthracotherium*. Five fragments of upper molars, of which the genus is indeterminate but which may possibly belong to the titanotheroid genus *Telmatherium*, have been described under a new specific name *birmanicum*. As these fossils are the first mammalian remains that have been found at such a low horizon in Asia, the determination of their age must be based rather on their stratigraphical position than on the evidence to be obtained from the fossils themselves; comparison with mammalian faunas of such remote regions as Europe and America could not be expected to give reliable results. At the same time such evidence of age as the fauna affords is, according to Messrs. Pilgrim and Cotter, in entire accord with that furnished by the stratigraphical relations of the Pondaung Sandstone, which underlies the Yaw stage with *Nummulites yawensis* Cotter, *Orthopharagmina sella* d'Arch., *Velates Schmideli* Chemn., *Cypræa elegans* Desh., and *Gosavia birmanica* Dalton, an assemblage which points decidedly to an upper eocene age.

14. **Tertiary Mollusca of Western India.**—Mr. Vredenburg has now completed a preliminary description of new species of the Tertiary *Mollusca* of

Sind; this will probably be published in a special volume of the *Memoirs* pending the preparation of a fuller and more detailed description of the whole material for publication in the *Palæontologia Indica.*

15. **Cretaceous and eocene of Tibet.**—In 's report last year reference was made to a memoir by M. Douvillé on the Cretaceous and eocene fossils collected in the neighbourhood of Kampa Dzong and Tüna in Tibet. It has now been decided, with the sanction of the Government of India, to publish M. Douvillé's work in the original French and it is hoped to issue it as a memoir of the *Palæontologia Indica* during the year 1916. The results of M. Douvillé's examination of the fossils are of considerable interest. The lower stages (neocomian to albian) of the Cretaceous are probably represented by certain unfossiliferous beds, the fossiliferous horizons beginning with the cenomanian which contains characteristic cephalopods belonging to the genera *Acanthoceras* and *Turrilites.* Professor Douvillé confirms most of the preliminary determinations published in that memoir and adds other forms not then identified; part of the supposed cenomanian has been removed by M. Douvillé to the turonian. A considerable number of fossils have been described from the Upper Cretaceous, including a new species of *Plagioptychus.* M. Douvillé regards as a new species the form determined by me as *Velates Schmideli* and describes it under the name *V. tibeticus;* he also regards the beds in which it occurs as Cretaceous rather than Tertiary and he has carried the boundary between the Cretaceous and Tertiary considerably higher than it was placed originally. His reasons for this appear to be based on the *Foraminifera* and chiefly on the occurrence and distribution of the *Orbitoides.*

16. **Echinoids of the Bagh Beds.**—M. Fourtau's re-examination of the echinoids of the Bagh Beds has led him to the conclusion that that stage is slightly older than has hitherto been supposed and that, instead of being of cenomanian age, it should be referred to the albian. M. Fourtau revises certain of the original determinations by Duncan (*Records, Geol. Surv., India,* XX, pp. 81-92) and re-describes seven species, of which five had been referred by Duncan to species already described either by d'Orbigny or by Cotteau; these five M. Fourtau regards as new species, and he has therefore given them specific names; they are *Salenia Keatingei* (=*S. Fraasi* Duncan), *Cyphosoma namadicum* (=*C. cenomanense* Duncan), *Echinobrissus Haydeni* (=*E. Goybeti* Duncan), *Hemiaster Oldhami* (=*H. cenomanensis* Duncan) and *Opisaster subsimilis* (=*N. similis* pars Duncan). M. Fourtau's paper was received in 1914 but has not yet been published as the preparation of the plates, which was undertaken by M. Gauthier in Paris, has been delayed owing to the war. It is hoped, however, that it may be possible to issue it shortly.

17. **Namyau Brachiopoda.**—Mr. S. S. Buckman was still engaged on the preparation of a memoir on the Jurassic brachiopoda from the Northern Shan States; this work which has led to a complete reclassification—already referred to in Vol. XLV *Rec., Geol. Surv. India,* —of the *Rhynchonellidæ*

and *Terebratulidæ* has proved to be more extensive than had originally been expected and the memoir has already extended from an estimated length of between 50 and 100 pages of the *Palæontologia Indica* to over 200; it is hoped, however, that it may be possible to issue the memoir during the course of the year 1916.

18. **Devonian fossils of Chitral and the Pamirs.**—Mr. F. R. Cowper Reed has very kindly undertaken, at my request, the description of a series of Devonian fossils collected by me in the course of a journey through Chitral and the Russian Pamirs in the summer of 1914. The specimens were sent to Mr. Reed last year, and he informs me that, so far, he has found among them only Upper Devonian forms. During the same journey I collected also Carboniferous and Jurassic fossils, but have not yet been able to make arrangements for their description.

19. **Revision of Gondwana cycads and conifers.**—A few years ago Prof. A. C. Seward suggested that it might be desirable, in the light of recent work to re-examine Feistmantel's original types of Upper Gondwana plants, more especially the cycads and the conifers; the collection was therefore forwarded to Prof. Seward, who is now studying it and hopes before long to be able to offer his results for publication by this Department.

20. **Fossil wood from Burma.**—At the suggestion of Professor Seward Miss R. Holden, who has been working at the Botany School, Cambridge, has offered to the Geological Survey, for publication in the *Records*, a paper by her on the fossil wood which is such a remarkable feature of the Upper Tertiary (Irrawaddian) beds of Burma. Hitherto no specimen had been completely worked out and described, partly owing to the difficulty of finding any in a sufficiently perfect state of preservation. Miss Holden however, obtained a fairly well-preserved specimen from Gwebindon in Sagaing district, and was able to make both longitudinal and transverse sections, from a study of which she has come to the conclusion that the wood is referable to the family *Dipterocarpaceæ*, and she names the species *Dipterocarpoxylon burmense*. It is hoped to include Miss Holden's paper in the current volume of the *Records*; its issue, however, will be delayed owing to the non-arrival of the plate, the whole edition of which had been prepared in England and was presumably lost on the S.S. *Persia*.

ECONOMIC ENQUIRIES.

Building Stone.

21. The serious decay of the stone of which the Town Hall of Simla was built led to the demolition of that building and since Viceregal Lodge at Simla was also built partly of the same material, it was decided that an investigation should be made in order to determine what steps should be taken for the preservation of the latter building. The stone chiefly employed is

grey limestone; this has been examined minutely by Mr. Tipper, who finds it to be crystalline and granular and to contain numerous accessory minerals, such as quartz, mica, iron pyrites, pyroxene and scapolite; cementing material is absent and there is very little interlocking of the grains. The rock has suffered from pressure which has produced either a finely crystalline structure or a rough foliated or banded arrangement of the constituent minerals. Mr. Tipper considers that the cause of decay of this rock is exposure to rain and moisture, for in protected situations the stone appears to be perfectly sound whilst the microscopical examination of the decayed material shows that the disintegration is not due to alteration of the constituent minerals, but has apparently resulted from a small amount of solution taking place round most of the calcite grains and thus leaving small spaces between them. Another rock employed in the construction of Viceregal Lodge is a soft argillaceous sandstone obtained from the Upper Tertiary beds at Kalka. Although of minor importance in the building it has suffered greatly from cracking; it has a very low degree of grain adhesion and is not suitable except for light work. Certain remedial measures have been suggested to arrest the decay of the limestone, but Mr. Tipper recommends that in all situations which are exposed to rain or moisture generally it should be replaced by better stone such as the Sanjauli quartzite.

Cobalt.

22. At the instigation of the Director of Industries, United Provinces, enquiries were made into the feasibility of obtaining cobalt oxide from the old mines in Jaipur, which have long been shut down in consequence of the import of purer and cheaper material from abroad. The chief demand for the oxide is connected with the indigenous bangle industry for which blue glass is required. In recent years enormous quantities of bangles have been imported, first from Austria and, since the outbreak of war, from Japan. It appears that the indigenous glass manufacturers imported their cobalt oxide also from Germany or Austria, instead of from Canada, the world's chief producer. On the outbreak of war the Indian consumer was unaware that he was purchasing an article which was a German re-export instead of dealing direct with the country in which it was manufactured and he was, therefore, put to inconvenience for some time for lack of his colouring material. He was subsequently put into touch with English exporters and there has recently been no difficulty in obtaining the oxide required. In the meantime a certain amount of work has been undertaken by the Jaipur Darbar in extracting samples of ore from the mines, and specimens have been sent to the Geological Survey for examination. In view, however, of the fact that the cobalt oxide is produced as a by-product in Canada it was considered improbable that the impure local material could compete with the imported article, and it was recommended that no further steps should be taken towards re-opening the mines. The case is interesting as an example of the manner in which Germany had captured the Indian market and was even

supplying it with a product practically the whole of which was produced in the British Empire.

Engineering Questions.

23. **Landslip on Upper Jhelum Canal.**—An extensive landslip having occurred at Mangla, the headworks of the Upper Jhelum Canal, the Secretary, Irrigation Department, Punjab, asked for a report on the local geological conditions; after inspecting the slip I arranged for Mr. A. M. Heron to spend a few days at the head-works and make a careful examination of the slip. The result has been to show that the conditions which led to it are not likely to recur if the necessary precautions are taken.

24. **Hill section, Assam-Bengal Railway.**—In consequence of the damage done to the hill section of the Assam-Bengal Railway by the excessive rain-fall of July 6th to 9th, 1915, the services of an officer of the Geological Survey were asked for by the Railway Board for a thorough examination of the hill-sides and cuttings. Mr. Coggin Brown was detailed to undertake this and visited the section in August last. He subsequently handed in a report in which he made various recommendations, which, if carried out, will minimise the danger of future slips.

Manganese.

25. In his Progress Report for the season under report Mr. Burton gives descriptions of numerous manganese-ore deposits, several of which have not been previously described. These latter are :—Saonri, Sailur, Chandi Nala, Garari Hurki, Chikmara, Chaukhandi, Saonghi-Atri, Bhansi, Nandgaon, Budbuda, Laugur, and Khara, all of which, with the exception of the two last-named, lie in the Katangi plain. Mr. Burton also gives notes amplifying descriptions previously given by Dr. Fermor of other deposits, and in particular supplies a series of interesting sections showing the results of over-thrusting at the Balaghat (Bharweli) manganese mine, and of the complicated folding that has affected the Thirori deposit. For various reasons Mr. Burton is inclined to refer these manganese deposits to two distinct horizons. The deposits of Balaghat, Laugur, Ukua, and Khara, demonstrably lie close to the base of the Chilpi Ghat series, the exact position in the succession of beds forming this series being on page 38. On the other hand the deposits situated in the Katangi plain, together with associated quartzites and muscovite-schists, are folded up with gneisses in an area of generally more intense metamorphism. Dr. Fermor, in his account of the deposits of this area,[1] attributed to greater general metamorphism at a lower altitude and presumed greater depth below the ancient surface any mineralogical differences that exist between these deposits and those associated with the Chilpi Ghat series in the Balaghat-Ukua syncline. The evidence is not yet

[1] *Mem., G. S. I.*, XXXVII, pp. 310-314; the discovery by Mr. Burton that the conglomeratic gneiss of Ukua is an autoclastic rock does not vitiate the argument.

decisive, but as a result of his more detailed survey, Mr. Burton is disposed to regard the Katangi group of deposits, together with the associated quartzites and muscovite-schists, as belonging to his Sonawani series, the type area of which lies in the hills to the north. His chief reasons for this are (1) the presence of a thin band of calc-granulite overlying the manganese ore band at Garari Hurki and to the east of Ponia in the Katangi plain; and (2) the existence in the Koka-dadar Lotan hill-mass, in the hills to the north of the Katangi plain, of a small outcrop of manganese-ore in contact with and probably underlying, a thin band of calc-granulite, which may be a much-diminished equivalent of the main mass of the Sonawani calc-granulites. As these latter lie at or near the base of the Sonawani series (see *Rec. G. S. I.*, XLV, p. 132) the occurrences referred to suggest that the manganese-ore deposits of the Katangi plain should also be referred to this stratigraphical position and grouped with the manganese-ore deposits associated with crystalline limestone referred to in the previous report (l.c.).

Mr. Burton also notes a case—at Bhansi in the Katangi plain—analogous to those described by Dr. Fermor from the Chhindwara district of pegmatite enclosing fragments of manganese-ore.

Molybdenite.

26. Towards the end of the year specimens of molybdenite were received from the Executive Engineer, Godavari Northern Division, Rajahmundry. The material consisted of pegmatite, containing a considerable quantity of molybdenite, which had been obtained from a well which was being sunk at Kunnavaram, in the Rajahmundry taluk of the Godavari Agency Tract. As molybdenite is at present worth about £600 per ton and is in considerable demand for the manufacture of high-speed tool-steel, it was considered advisable to investigate the occurrence at once. Mr. G. de P. Cotter proceeded to the locality but after a careful examination of the neighbourhood has come to the conclusion that the occurrence is merely sporadic and that there is no reason to suppose that any large quantity will be found.[2]

Petroleum.

27. **Burma.**—Oil-shows were found by Mr. Cotter in various parts of the country mapped by him during the field-season in Pakokku district, especially along the Myaing anticline and near Kyaukwet (sheet 84K-10). The structure, however, is unfavourable owing to the intense faulting. Seven miles south-west of Kyaukwet, near the village of Palangaing, there is a gentle anticline of Pegu beds rising from beneath the Irrawaddy sandstones, but it is very doubtful whether it is worth testing.

[2] Mr. Cotter's visit to Kunnavaram was paid actually in the beginning of the year 1916 and does not, therefore, strictly speaking, fall within the period with which the present report deals, but owing to the importance of the mineral at present, it has seemed advisable to publish this information at once.

28. **Punjab.**—During the earlier part of the year, Dr. E. H. Pascoe continued his investigation of the known oil seepages in the Punjab; he visited Jaba, Isa Khel, Mardwal, Khabakki, Khaur, Sudkal, Chharat, Murat and Misnot. Most of these localities appeared to offer no great hopes of successful exploitation, but at Mardwal and Khabakki seepages occur on an open anticline of favourable shape and with gentle dips; the rocks, however, are hard and impervious. At Khaur, where a seepage was found by Mr. E. S. Pinfold, the structure appears to be highly favourable over an extensive area and a well put down on behalf of the Attock Oil Company struck oil at a short distance below the surface. I visited the field in November and found that steps were being taken to test it thoroughly with a view to energetic development. The results of these tests will be awaited with interest, more especially as the oil occurs at a horizon considerably higher than that at which it has been found in Burma and if its present position is due, as suggested by Mr. Pinfold, to migration from lower horizons, its occurrence in any considerable quantity will very greatly enlarge the field over which search for oil may be made in the Punjab with reasonable hopes of success.

Potash Salts.

29. The investigations, referred to in a previous report with regard to the potash salts of the Salt Range, were continued during the year under review, first by Dr. E. H. Pascoe and subsequently by Dr. M. Stuart, the latter officer having been detailed to examine the numerous outcrops of salt which occur in the Nilawan ravine. Dr. Stuart's investigations are not yet complete, but, so far as they go, offer no great hopes of the discovery of large quantities of potash salts. The band previously discovered in the Nurpur mine has been followed for some little distance and found to be continuous; should it extend further down the ravine beyond the mine, it should be possible to trace it among the outcrops. This, however, will involve time and a considerable amount of excavation since, owing to their greater solubility, potash salts may be absent from outcrops while present in deeper parts of the beds which have not been exposed to the leaching effect of surface waters. Potash bearing material has also been found at the Warcha mine.

Pyrite.

30. At Hungwe (23° 7′ : 97° 11′) and near Man Pat (23° 12′ : 97° 11′) in the Northern Shan States, Mr. Brown found several quartz veins carrying large quantities of iron pyrites which, however, did not yield any gold or other valuable metal when subsequently assayed. The inaccessible nature of the locality renders the pyrites of no value at present as a source of sulphuric acid.

Tungsten.

31. The fact that practically the whole supply of tungsten and ferro-tungsten used by Great Britain before the war was obtained from Germany

led to a great scarcity of those materials during the year 1915 and steps were taken to establish works in England for the manufacture of ferro-tungsten tungsten and steel in the country. The company known as the High-Speed Steel Alloys was formed for this purpose and works were erected at Widnes in Lancashire. In consequence of the greatly increased amount of tungsten steel required in connection with the manufacture of munitions, steps were next taken to increase as far as possible the output of the raw material, and all wolfram produced in the British Empire was ear-marked for despatch to the United Kingdom ; in order to provide against any possible attempt to hold up ore all shipments reaching British ports were taken over by the British Government at a fixed rate of 55*s*. pe unit of WO_3 on a basis of 65 per cent. ore and were distributed to manufacturers through brokers appointed for that purpose.

32. **Tavoy.**—The increase of price from the pre-war rate of abou 30*s*. per unit to 55*s*. might have been expected to lead to a great increase in local mining activity in Tavoy, which district is the chief source of wolfram in the British Empire ; this expectation was not realised and it became necessary for the Local Government to step in and insist on concessionaires fulfilling the terms of their contracts by working energetically and efficiently. For this purpose the Government of Burma appointed the Deputy Commissioner, Tavoy, whose experience of the industry had already extended over a year and half, as special officer in charge of the mining administration of the Tavoy district. It was further decided that a member of the Geological Survey should be associated with the Deputy Commissioner as expert technical adviser, and also to assist mine-owners, many of whom had no mining engineers in their employ, with advice as to the best methods by which to develop their properties. Mr. Brown's extensive knowledge and long practical experience of ore-bodies and metal mining made him eminently suited for appointment in this capacity and his selection has been abundantly justified by the results already attained. With him are also associated Sub-Assistants S. Sethu Rama Rau and M Vinayak Rao, the one to assist Mr. Brown in the examination of existing properties and the other to search for new ore-bodies. Mr. Brown arrived in Tavoy shortly after the middle of October and by December 31st, the end of the period with which this review deals, he had made altogether over 50 inspections and this in spite of the fact that the properties inspected lie in all parts of the Tavoy district and often at a distance of 50 miles or more from Tavoy, while at the time of Mr. Brown's arrival only two properties were accessible by any road along which wheeled traffic other than bullock carts could travel. In addition to the measures taken for the inspection of the properties, a considerable labour force has been imported to meet the requirements of those local producers who are unable to import labour for themselves. In view of the considerable increase already attained owing to the efforts of the highly efficient administrator with whom Mr. Brown is associated, it may safely be anticipated that the coming year will see a large increase in the total output from Tavoy. The

most rudimentary knowledge, however, of mines and mining methods, more particularly where metal mining is concerned, must make it clear that increased output cannot be expected as the immediate result of an increased labour force, since development, which involves driving through hard rocks, such as the quartz lodes and granite of Tavoy, can only proceed at a limited pace. No great increase th refore over the output now attained can be expected for some months, until in fact a considerable amount of development has been done. The present season is also unfavourable for increased output since water is not now available for alluvial mining and most of the output must therefore come from the reefs until May, after which the rainy season will provide water for sluicing purposes.

33. **Mergui and Mawchi.**—With a view to increasing the output of other districts Mr. H. Walker was deputed to inspect and report on wolfram-bearing areas in Mergui, as well as on the Mawchi mine in the Bawlake State of Karenni. It is hoped that this recommendation may lead to an increased output in these areas also.

34. **Rajputana.**—In the *General Report* of the Geological Survey for the year 1913 reference was made to the occurrence of wolfram near Degana railway station on the Jodhpur-Bikaner Railway. The wolfram occurs in quartz-veins in three small hills and an attempt has recently been made to extract and export the ore. I visited the locality during a recent tour in Rajputana. The hills consist chiefly of granite penetrated by a number of veins which are approximately vertical and run either NW-SE or NNW-SSE. From the plain at the foot of the largest of the three hills the veins are seen very clearly running up the face of the hills, which is about 500 feet high. The veins consist usually of coarsely crystallised mica on the outside edges next to the country, with quartz and wolfram in the centre. The wolfram, however, sometimes occurs also with the mica. The veins are usually from a few inches to a foot in thickness, but in some instances, as on the north-western side of the big hill, they are two or three feet wide. In one place on that side of the hill there is a very large mass of qu ıtz probably 20 feet by 20 feet and of unknown depth, which contains considerable quantities of wolfram. Work is being carried on now in a large number of places on the big hill and on a small hillock to the south-west of it. The veins are being worked by open quarries, but so far the amount of work done is quite insignificant and amounts only to preliminary prospecting. I was unable to ascertain the average value of the veins that are being worked, as the present workings are too small and too local to give reliable results; they are, however, sufficiently rich to make working under present conditions a profitable enterprise. Labour is cheap, unskilled workmen being paid 4 or 5 annas per diem and blasting *mistris* one rupee. Small parties of workmen are engaged at various points quarrying out the lodes, some working near the foot of the hill, others higher up and some near the top. The disposition of the lodes, which are vertical, makes quarrying a perfectly straightforward operation, but the present method of working high up on

the hill-side from above downwards will no doubt be discarded when the work has extended beyond the prospecting stage, when it will be advisable to mine by means of galleries at various elevations. Most of the veins at present exposed are thin, and if the price of wolfram falls appreciably in the future, it is possible that the cost of extraction at Degana may become prohibitive, since every inch of rock has to be blasted. Mining will therefore be expensive. If we assume—which seems justifiable—that the veins are on the average as good inside the hill as they are on the surface, there is undoubtedly a considerable amount of wolfram to be had here. The amount being won at present is very small, since the concessionaires are working on quite a small scale, their output at present being, I understand, only about 1½ cwt. per diem. By increasing the number of working places and by a corresponding increase of labour staff, they ought to be able to treble or quadruple their output. This they will probably do as they begin to find their feet, for it will be to their interest to extract as much ore as they possibly can while the present inflated prices continue to prevail. The future of the property will depend on the condition of the wolfram market when conditions again become normal after the end of the war. If the more superficial workings prove the veins to be continuous and fairly rich, it may ultimately pay to undertake deep mining. At present the extent of the veins is unknown; the hills in which they occur stand out in a small isolated group completely surrounded by sand and alluvium. The life of the mine will therefore ultimately depend on the depth below the plain level to which workings can be carried profitably.

35. **Singhbhum.**—Specimens of wolfram, said to have been found in Singhbhum, have also been recently received by the Geological Survey.

GEOLOGICAL SURVEYS.

Bombay, Central India and Rajputana.

36. **Mr. Heron : Kishengarh and Ajmer-Merwara.**—Mr. Heron continued his survey of the Aravalli region in a southerly direction by taking up the re-mapping of Kishengarh State and the British district of Ajmer-Merwara, together with a small portion of Marwar (Jodhpur) State immediately adjoining the western border of Kishengarh. The Standard (1″=1 mile) sheets of the Central India and Rajputana Survey worked on are Nos. 166 and 196 to 199, of which Nos. 196 and 198 are now completed except for the portions of Jodhpur State included in No. 196. Up to March 25th Mr. Heron had the co-operation of Dr. Stuart over sheets 196 to 199.

37. Apart from alluvium, which presents no features of novelty, the rocks were found to consist of members of the Aravalli system to the south-east of a line running past Kishengarh city, and the Delhi system to the north-west of that line; the former, as surveyed principally in sheet 198, being monotonous series of dark schists or granulites, composed of biotite, quartz

and microcline, with a little muscovite, garnet, apatite and iron ores, and occasionally, sillimanite or (?) andalusite. A few discontinuous and lenticular patches of quartzite occur among these, but they were found to be always dark-coloured, impure and micaceous or garnetiferous, differing materially from the quartzites of the overlying Delhi system. Mr. Heron is disposed to regard these Aravalli schists as possibly very highly altered sedimentary rocks.

38. The Delhi system, chiefly developed north-west of the line of Kishengarh city, presented new and formidable difficulties owing to the presence of various new types, such that the division of them into Ajabgarhs and Alwars (as in the eastern Rajputana areas) is now no longer feasible. As the full succession is at present doubtful, it will be convenient to await the results of further work in the better exposed and more continuous sections near Beawar before going into details concerning it. Briefly the system, as at present regarded, comprises a varied assemblage of quartzite, arkose, conglomerate, siliceous and biotitic limestone, white marble, ferruginous limestone, biotite and muscovite schists, garnetiferous schist, talc and chlorite schists, serpentine and tremolite quartzite (calc-gneiss), all arranged in more or less parallel outcrops among which the quartzites stand up prominently as elevated ridges. Most of this vast assemblage has the appearance of holding together in some sort of sequence and builds a type of country very different from the normal Aravalli country to the south-east and most of it without much doubt must be placed with the Delhis, *i.e.*, with a system separated by an unconformity, with thick conglomerate, from the older Aravalli formations.

39. The igneous rocks of the area may be referred to briefly as a whole. In interest and variety they surpass those found in the Delhis in previous years. They embrace (1) fine-grained granite pegmatites with biotite, which are injected into the Aravalli schists in great profusion, producing the "migmatite" of Sederholm : these are confined to the Aravallis and are pre-Delhi in age ; (2) coarse granite pegmatites with muscovite and tourmaline, which pierce both Aravallis and Delhis ; (3) intrusive granite in masses of all sizes, from 9 miles wide downwards, of which Mr. Heron recognises many types according to the mineral character and degree of foliation found, some of these being post-Delhi and others pre-Delhi and truncated by the basal Delhi conglomerate ; (4) the well-known elæolite syenites and related old intrusives (which Mr. Heron proposes to describe in a special paper) ; (5) amphibolites resembling those described in previous years in Alwar and Jaipur, and found intrusive in both Aravallis and Delhis, though best developed in the ridges of Delhi Quartzite ; (6) a few other miscellaneous types, some of doubtful igneous origin, including coarsely crystalline garnet rock, serpentine, dolerite (with olivine) and a few others.

40. **Dr. M. Stuart.**—Dr. Stuart, besides being associated with Mr. Heron in the above-mentioned investigations, spent a short time alone near the end of the season in a limited area on sheet 198 with the specific object of

mapping the lithological variations found in the parallel bands of the complicated Delhi rocks. Dr. Stuart has sent in a separate progress report on this subject and, in so far as a brief summary can do, his results have been included in the above notes referring to his work jointly with that of Mr. Heron.

41. This brief reference to the work done in Rajputana, with its implication of many abstruse problems still awaiting solution, is necessarily an incomplete statement of the numerous partial solutions and descriptions that appear in the full reports by Mr. Heron and Dr. Stuart, but which, in consideration of the extremely difficult nature of this crystalline complex, may perhaps with advantage await the fruits of fuller and more intimate knowledge before being further discussed in greater detail.

42. **The Director, Mr. Middlemiss, Mr. Vredenburg and Mr. Heron : Karauli State.**—While in temporary charge of the Central India and Rajputana party Mr. Vredenburg had occasion to visit certain parts of Karauli State which had been mapped by Hacket in the years 1869 and 1882 ; the survey had been revised by Mr. Heron during the season 1913-14 and Mr. Vredenburg found himself unable to accept the interpretation of the stratigraphy and the classification finally adopted. Mr. Heron had referred the rocks to one or other member of the Vindhyan system and believed that he had recognized all the stages between the Tirohan breccia and the Upper Bhander sandstone. As the question is one of prime importance so far as the re-survey of this part of Rajputana is concerned, it was decided that the ground should be visited by me, with Messrs. Middlemiss, Vredenburg and Heron, and the question of correlation examined in detail. On the way, visits were paid to the type section of the Tirohan limestone and breccia near Karwi in the Banda district of the United Provinces and to sections of the Gwalior system in Gwalior State. Subsequent re-examination of the rocks of Karauli made it clear to all members of the party, including Mr. Vredenburg, that the classification adopted by Mr. Heron was correct and that the contrary opinion at first held by Mr. Vredenburg was due partly to a misinterpreted section and partly to the unusual degree of induration of the Bhander sandstone in Karauli, which gives it a superficial resemblance to rocks of considerably greater age. Mr. Heron's work throughout the area visited proved to be careful, accurate and reliable.

Burma.

43. **Mr. G. de P. Cotter and Sub-Assistant Sethu Rama Rau : Pakokku and Thayetmyo.**—Mr. G. de P. Cotter continued the survey of Pakokku district to the northward of the area mapped during the preceding season. A strip of country, some 60 miles broad, from the neighbourhood of Myaing to Tilin, was mapped on the scale of 1″ = 1 mile. This strip lies between latitudes 21° 30′ and 21° 45′. Near Myaing (sheet 84K-14) a faulted anticline runs NNW-SSE exposing rocks from the Irrawaddy Sandstones

and Pegus above to the Pondaung Sandstones at the base. These last are especially interesting since they contain remains of the Eocene mammals already referred to under the section " Palæontology " (*supra*, para. 13). In the Tilin area freshwater sandstones, containing remains of *Rhinoceros sp. cf. sivalensis* and therefore of Upper Tertiary age, rest unconformably upon lower eocene beds. These freshwater beds are probably to be correlated with the Irrawaddy Sandstones, but have been termed locally the Maw Gravels.

In general the results of the previous season were confirmed, and additional evidence was obtained to prove the establishment of estuarine and freshwater conditions at an earlier age in the more northerly region of the Irrawaddy basin.

44. Sub-Assistant Sethu Rama Rau was engaged in systematic survey work in parts of the Thayetmyo district covered by sheets 158 and 159 of the Burma Survey (1″=1 mile). During the earlier part of the year, he examined several anticlines including those of Uyin, Kyawdo-Sanaing and Yein-Tamagyaw. The two last-named are in either the Sitsayan Shales or lower horizons and are formed chiefly of argillaceous limestone or indurated calcareous shale with subordinate bands of sandstone. The Uyin anticline was traced up to Kyebyongyi, and has been found to extend over a length of more than seven miles (see above, under *Petroleum*).

45. **Mr. J. C. Brown : N. Shan States.**—During the latter part of the field-season of 1914-15, Mr. Brown took up the systematic survey of the country lying to the west and north of the Bawdwin area, and succeeded in mapping some 500 square miles of new country. On his way to the field he revisited the Bawdwin mine and made a further detailed study of the silver-lead-zinc-bearing lodes ; this led to some interesting results which may be of considerable importance from the economic point of view, for he has now definitely ascertained that the metalliferous lodes are confined to kaolinised and chloritised tuffs and not, as hitherto supposed, to a sedimentary series of felspathic grits ; he also found evidence to show that the assumption that the ore-channel was limited by faults which had occurred after the mineralisation of the lodes was incorrect and that the Bawdwin series of igneous rocks extended over a considerably larger area than had previously been imagined. He now considers it probable that the sediments which overlie the Bawdwin rhyolites and tuffs represent the lower part of the Naungkangyi beds of the Northern Shan States and are therefore of Lower Ordovician age.

46. After leaving Bawdwin, Mr. Brown proceeded to link up the map of that area with that of the previously mapped districts further to the south. He then continued westwards and northwards into the Tawngpeng (23° : 97°) and Mong Long (22° 50′ : 96° 40′) areas, in order to demarcate the boundaries of the intrusive Tawngpeng granite along its junction with the mica schists of Mong Long and the Chaung Magyi phyllites and slates ; the boundary with the latter series proved to be an intricate one and, in the

neighbourhood of Hai-taung (23° 4′ : 97° 13′), a great tongue of granite was found to extend to within six or seven miles of the Bawdwin metalliferous area. The granite is a coarse, tourmaline-bearing rock, frequently containing large felspar phenocrysts ; it is always decomposed to a considerable depth, but is still hard enough to form the maze of branching ranges and deep ravines so characteristic of Northern Tawngpeng Basic dykes, chielly of olivine gabbro, are occasionally found in the granite.

47. A study of the country round Lao-ka-ya (23° 10′ : 97° 18′) and Mansak (23° 12′ : 97° 19′) threw further light on the question of the stratigraphical position of the sediments which overlie the Bawdwin rhyolites ; they were found to underlie the lowest fossiliferous members of the Naungkangyi series and to lie conformably on the Bawdwin volcanic series ; although they are unfossiliferous, their position indicates that there age is either Lower Ordovician or Cambrian. Mr. Brown has named this sedimentary group the Pang-yün stage, from the name of the river in which they are most clearly seen.

In the neighbourhood of Mong-yok (23°13′ : 97°18′) outliers of Plateau Limestone were found lying directly on the much older Pang-yün stage.

Central Provinces.

48. **Dr. L. L. Fermor : Chhindwara.**—During a short field season Dr. Fermor continued the geological survey of the Sausar tahsil of the Chhindwara district, where the formations studied were, as before, the Archæan gneisses and schists, the Intratrappeans, the Deccan Trap, and the alluvium, older and newer.

Comprised in the Archæans are two main divisions, namely orthogneisses and schists, and rocks that are partly or entirely of sedimentary origin. The orthogneisses of the Sausar tahsil are predominantly biotite-gneisses, of which there are many varieties. The predominant felspar is microcline, but oligoclase, labradorite, and orthoclase also often occur. In places these gneisses are richly garnetiferous, sometimes apparently owing to pressure, but not always so. They also occasionally contain sillimanite, but the evidence indicates that the presence of that mineral is due to pressure and is not to be taken as an index of the presence of assimilated sedimentary material. There are also numerous basic hornblendic bands, the exact relationship of which to the biotite-gneisses is not known. It may be significant, however, that these hornblendic bands gradate into a hornblende-gneiss apparently indistinguishable from the gneiss referred to below.

49. Intrusive in the biotite-gneiss is a great variety of pegmatites and granites. The former are predominantly muscovitic and the latter usually biotitic. From the latter there appears to be a gradation into the porphyritic gneisses interbanded with the non-porphyritic gneisses of the general complex, so that the porphyritic gneisses and augen-gneisses (often rolled out into streaky gneisses) may be younger than, and intrusive into, the typical

nonporphyritic fine-grained biotite-gneiss of the Sausar tahsil. Excluding provisionally the hornblendic gneisses, Dr. Fermor regards the entire orthogneiss-granite-pegmatite complex as due to a succession of eruption of various differentiation phases of one general primordial magma.

50. The paragneisses and schists include calc-gneisses and granulites, calciphyres, crystalline limestones, and gonditic rocks. The origin of the various calcareous rocks, as studied by both Dr. Fermor in this area and by Mr. Burton in the Balaghat district, was discussed at some length in a previous report. The conclusion arrived at was that the calc-gneisses and granulites are to be regarded as hybrids of a calcareous sediment and an acid intrusive. Near Jirola in the Sausar tahsil Dr. Fermor has found a series of rocks formed by the admixture of calc-granulite with the prevalent fine-grained biotite-gneiss of this area. Often the constituents of the two rocks have been imperfectly mixed and the ferro-magnesian constituents of the resultant compound rock are patchily distributed, the calc-granulite being represented by patches rich in hornblende, and the orthogneiss by patches rich in biotite. When the admixture has been more complete the hornblende and biotite are uniformly distributed, and, as the calc-granulite is itself regarded as a hybrid, the biotite-hornblende-gneiss must be regarded as a hybrid of the second order. This latter rock is of frequent occurrence in the orthogneissic complex of the Sausar tahsil, and suggests the wide distribution of altered remnants of the sedimentary calcareous series away from the main outcrops.

51. No fresh information was elicited concerning the Intratrappeans. In the previous report reference was made to the discovery of a spindle-shaped fault-block near Utekata, and to the probability that the Kanhan valley, which lies immediately to the west of Utekata, is occupied by an important fault striking SSE, with a downthrow of about 250 feet to the west. From a study of data collected in previous years in the Nagpur district to the south, Dr. Fermor deduces that this fault probably continues southward as far as the latitude of Nagpur, passing somewhere between Nagpur and Kamptee, and accounting for the fact that the base of the Deccan Trap at Nagpur lies at an elevation of slightly under 1,000 feet above sea-level, whereas the Suradevi Hills of Kamthi sandstone near Kamptee reach a height of 1,070 feet without being capped by trap. This gives the fault a length of 50 miles, but it must be left to the future to show whether it is a case of one continuous fault or of a zone of faulting. As there is no evidence that the fault continues to the north of Ramakona as a factor of any importance, it is probable that the Utekata fault-block, the long axis of which is aligned E by S, is a part of the cross-faulting marking the northward termination of the Kanhan fault. A search for the continuation of the Utekata line of cross-faulting on the west side of the Kanhan fault in the neighbourhood of the villages of Kuddam and Khajarwani proved successful, but the faulting was found to be much more complex than expected. There appears to be a total downthrow of 176 feet to the south, the algebraic sum of numer-

ous block-faults of small throw (often only 20 feet). It is possible also that the fall in the level of the base of the Deccan Trap from about 1,300 feet at the latitude of Ramakona to about 1,000 feet at Nagpur, will prove to be the algebraic sum of a system of block-faulting bounded on the east side by the great SSE fault, to the existence of which the formation of the Kanhan valley must be attributed.

52. The older alluvium covers large areas in the Kanhan valley, is as much as 80 feet thick, and is lithologically distinguished from the newer alluvium by the presence of a great abundance of kankar, as in the case of the older and newer alluvia of the Ganges and other Indian rivers. The erosion to which the older alluvium is now being subjected indicates a recent depression of the lower reaches of the river relative to the upper reaches, with a consequent steepening of the gradient. From one of the beds of conglomerate in the older alluvium, Dr. Fermor extracted a worked Pahlæolithic chert core. As undoubted worked flakes of Neolithic type are commonly found on the surface of the older alluvium, we have evidence in this valley of the existence of two alluvia with corresponding periods of stone implements.

53. **Mr. H. Walker : Betul.**—Mr. Walker continued his survey of the Betul district, working during the greater part of the season in the country to the west and north of Chicholi at the west end of the district, and at the end of the season in the Deccan Trap ghat country forming the south-western corner of the district. The Chicholi tract is occupied by alluvium, Deccan Trap, Archæan granites (and gneisses), and an intervening formation composed of grits, with conglomerate. These grits were noticed by W. T. Blanford, who, in his account of the geology of Western India (*Mem., G. S. I.*, VI, p. 53), mapped them as Mahadevas, but evidently regarded their age as uncertain and even considered the possibility of two series having been included under one name. Mr. Walker finds a portion of these rocks to be horizontal and a portion to be inclined, sometimes steeply, apparently as the result of faulting. He regards the two portions as of the same age in spite of certain differences, but has not arrived at a definite conclusion as to what this age is ; he favours the idea that they are Talchirs rather than Lametas, which latter is suggested by many features.

54. The crystalline rocks in the Chicholi tract consist, to the north-west and north of Chicholi, principally of porphyritic granites, which have been converted into augen-gneisses in the neighbourhood of Sitadongri and to the north. Intrusive into these granites and augen-gneisses is a fine-grained acid granite ; and of still later age are veins of pegmatite. Further south (between Alampur and Gondra) and east (near Bagla) the crystalline rocks are gneissose granites and schistose gneisses, all biotitic, with associated older amphibolites and lamellar quartzites in the latter area.

55. Mr. Walker has found several dykes of Deccan Trap age in the Moran River between Tendukhera and Sitadongri ; one is composite and pierces

basalt, whilst another encloses masses of the porphyritic granite that it traverses.

56. **Mr. K. Hallowes : Mandla.**—Throughout the field season Mr. K. A. Hallowes was engaged in separating and mapping in detail an area of the Deccan Trap flows round Narainganj in the Mandla district, completing the survey of 120 square miles of country on the lines of the work carried out by Messrs. Fermor and Fox in the Linga tract of the Chhindwara district. Eight flows are distinguished in descending order ; of these the middle six have an average thickness each of about 108 feet. In composition all the flows prove to be basaltic, showing in every flow, although not in every specimen, signs of the presence of olivine, usually completely altered to serpentine, but occasionally fresh in parts. In texture the rocks range from fine-grained basalts to dolerites of fairly coarse grain. According to the field evidence all these lavas, irrespective of texture, must be regarded as surface flows. No evidence was obtained that any of the flows die out in the area examined, so that the work indicates once more the great fluidity of the Deccan Trap lavas at the time of eruption. The discovery of two small faults near Kekra was referred to in the previous report but work carried out during the remainder of the season did not lead to the discovery of any other faults, nor did Mr. Hallowes find any evidence of folding such as has been discovered in the Linga tract.

57. **Mr. R. C. Burton : Balaghat.**—Mr. Burton continued his survey of Balaghat district and completed the survey of the Katangi-Waraseoni plain west of the Wainganga ; he also surveyed a considerable area to the east of this river, including the western portions of the Baihar plateau. On the plateau, outliers of Deccan Trap capped by latertite were found in the Kothi Pat hill-mass between Laughar and Sarad and in the Tipagarh hill-mass north of Samnapur. The laterite is frequently bauxite of good quality, is over 100 feet thick, and is underlain by lithomargic clays 100 feet thick which pass down into the Deccan Trap, showing that this laterite has been formed *in situ*. Laterite up to 30 feet has also been formed *in situ* on gneiss and Chilpi phyllites. With the exception of the above two formations and the widespread alluvium of the Wainganga and other streams, the whole of the area surveyed is occupied by Archæan rocks, amongst which Mr. Burton recognises the following divisions :—

(1) Later intrusive granite and porphyritic gneiss ;

(2) Older, more basic, biotite-gneiss, also intrusive into the older sediments ;

(3) Chilpi Ghat series with manganese-ores ;

(4) Sonawani series.

The work on the Sonawani series, including the calc-granulites, was summarised in the preceding report ; otherwise the chief interest in Mr. Burton's Progress Report is concerned with the constitution and stratigraphy of the

Chilpi Ghat series. In the area examined that series crops out as a long synclinal strip from west of Waraseoni, past Balaghat, to Ukua, a total distance of some 40 miles (the Waraseoni-Bhimlat band of Mr. P. N. Bose). This syncline strikes roughly NE and has a relatively straight NW margin and a sinuous SE margin, the Chilpis being bounded on each margin by one or other of the intrusive gneisses. Along the SE margin of the syncline the Chilpis dip at relatively low angles to the NW quadrant and are separated from the underlying gneisses by a plane of over-thrust which can be particularly well studied along the flanks of the ridge on which the Balaghat or Bharweli manganese mine is situated. In this ridge the thrust brings each of the three basal members of the Chilpi series in turn into contact with the gneiss. As the latter has been converted into autoclastic conglomerates and breccias along the boundary, whilst the basement bed of the Chilpis consists of sedimentary conglomerates and grits, the junction is sometimes difficult to fix exactly. Along the NW edge of the syncline the Chilpi phyllites have been converted into sericite-schists, whilst in places the gneiss with which they are in contact has been converted by pressure into a series of biotitic sericite-schists and fine-grained crushed gneisses. As most of the biotite and felspar in these crushed rocks has been converted into sericite, we have here an interesting case of convergence of types, biotite-gneiss and sedimentary phyllite each yielding sericite-schist under the influence of pressure. The rocks at the north-western boundary of the syncline are disposed either vertically or with a steep dip to the NW quadrant. But to what extent there is actual rupture accompanied by overthrust faulting on this boundary is at present undetermined. Taking all the evidence into account Mr. Burton concludes that the thrust movement that has produced the phenomena recorded has come from the north-west.

58. As a result of the work so far completed Mr. Burton finds that the Chilpi Ghat series consists of the following beds, with the approximate thicknesses stated :—

	Feet.
1. Basement conglomerate and grits . . .	0 to 900
2. Phyllites and jasperoid quartzites . . .	200
3. Manganese-ore	0 to 50
4. Phyllites	3,500 to 5,000
5. Blue slates, slaty quartzites, and felspathic tuffs	9 to 1,800
6. Phyllites, sericite-schists derived from phyllites, psammites, and thin felspathic tuffs . .	2,500
	6,200 to 10,450

It is anticipated that work further east may bring in still higher members of the series.

59. Of the two gneisses recognised the older is a fine-grained biotite-gneiss, and the younger a more acid porphyritic biotite-gneiss, the two being,

probably, equivalent to the two main divisions recognised in the orthogneisses of the Sausar tahsil of the Chhindwara district (see para. 50). The younger porphyritic gneiss forms a large batholithic mass in the northern part of the district and disappears under the Deccan Trap of the Mandla district: to the north of the Mandla trap lies the pink porphyritic granite of Jubbulpore, which is regarded by Mr. Burton as a part of the same batholith. Near the Chilpi boundary, on its northern edge, the older gneiss often contains thin bands of kyanite-bearing gneisses, which are regarded as contact rocks produced at the time of intrusion of the gneiss into the Chilpis, when some sedimentary material must have been caught up in the gneiss.

Nizam's Dominions.

60. **Mr. K. A. K. Hallowes : Hyderabad.**—While progress has been made towards the completion of the geological map of India in other parts of the country, a large gap has long been conspicuous on the eastern boundary of the Nizam's Dominions in longitude 77°-79° and latitude 18°-19°. Although it is not at present desirable to take up the survey of this area in detail, it has been decided to determine broadly the distribution of the Deccan Trap and crystalline rocks respectively and so to complete this part of the geological map of India on a scale of 1″=32 miles. For this purpose, with the approval of the Government of India and the sanction of His Highness the Nizam, Mr. K. A. K. Hallowes was detailed to make a traverse across the area involved, following the eastern boundary of the trap. This work if carried out on the ¼″ scale should occupy only three or four months and should therefore be completed during the present field-season.

Sind.

61. Sub-Assistant M. Vinayak Rao was detailed to examine, and with the assistance of Babu Bankim Bihari Gupta, Field Collector, to collect from, the Manchhar beds of Sind. He mapped these beds in the Karachi and Larkana districts comprised on sheets 5 to 9, 22, 26 to 30, 46 and 47 of the Sind Survey (1″=1 mile). Mr. Vinayak Rao has submitted the following notes on the general results of his work: "The Upper and Lower Manchhars are of the same type as the Upper and Lower Siwaliks, which are their equivalents in the Punjab, but differ from them somewhat lithologically in the lower horizons. Fossils are not abundant as in the Punjab. The beds attain their maximum thickness on the Gaj, where only a few horizons of the Upper, Middle and Lower Siwaliks are present. To the south they thin out and in Southern Sind the Middle Siwaliks are wanting. In some areas there are only about 100 feet of Upper Manchhars and 100 feet of Lower Manchhars.

"Estuarine conditions have prevailed in early Manchhar times in Upper Sind, as is evidenced by the presence of shells on the Gaj river. In these

beds estuarine shells are found in the Upper Manchhars on the coast a few miles east of Karachi.

"Manchhar beds, both Upper and Lower, have been much disturbed along the flanks of the Khirthar and Laki ranges and the continuation of these hills, but eastward in the valley of the Indus and along the coast near Karachi the disturbance has not been great."

GEODESY.

BY

COLONEL G. P. LENOX-CONYNGHAM, R.E.,

Superintendent of the Trigonometrical Survey.

PRINCIPAL TRIANGULATION.

A detachment of 15 Party in 1915-16 was deputed to revise the southern connexion of the Manipur Meridional Series with the Burma Coast Series, as the southern triangle of the former, which was observed very late in season 1901-02, exhibited a large error. The Burma Triangulation is about to be adjusted, making it desirable to revise the observations and ensure a satisfactory connexion. The work lay in the Akyab and Kyaukpyu districts of the Arakan division in Lower Burma and it was thought that the re-observing of two or three stations would have been sufficient to locate the error; but owing to the destruction of two of the old station pillars, it proved necessary to observe at four stations. This was successfully carried out in spite of the difficult nature of the country, which consisted for the most part of innumerable creeks separated by mangrove forests and swamps. The triangles were observed with Troughton and Simms' 12-Inch Theodolite No. II and the average triangular error was 0″·64. This is satisfactory considering that the stations were unfavourably situated, several rays grazing badly over intervening hill ranges, with the result that the heliotropes and lamps appeared most unsteady and were difficult to intersect accurately.

The detachment also undertook the observation of two astronomical azimuths and two latitudes, the results of which are summarized below. The latter were observed on the circum-meridian plan and the results show a very satisfactory degree of precision, the probable errors being 0″·16 and 0″·13, respectively. The probable error of a single observation in each case was 2″·0.

The results are exhibited in tabular form (see table in next page) together with those previously obtained at the adjacent station of Dattaung.

The values of the Latitudes, Longitudes and Azimuths from which the deflections are deduced are in final terms of the Burma Coast Series, computed from the finally adjusted values of the Indian triangulation. These values will be slightly modified when the Burma triangulation is adjusted as a whole.

Astronomical Latitudes and Longitudes.

Name of station.	Latitude.	Longitude.	Height in feet.	Deflection of plumb line. (Positive values indicate westerly or southerly deflection.) A—G in meridian.	(A—G) contd in prime vertical.	
	° ′	° ′		″	″	
Yeponetaung H. S.	20 15	93 42	2,819	—4·19 [—6·0]	—24·4 [—16·6]	About 20 miles inland from Burma Coast with high ranges to North and East.
Retkamauk H. S.	19 48	93 28	1,585	—1·28 [—3·3]	—9·2 [—1·4]	On an island practically on Coast line.
Dattaung H. S.	20 13	93 1	..	+2·0 [+0·2]	—10·3* [—5·0]	* Adjusted on the Akyab electro-telegraphic longitude results.
				Values in square brackets are in terms of most recent spheroid. $\alpha=6378200$ m. $\frac{1}{3}=298{\cdot}3$		

Azimuth Observations.—A correction of $+2''{\cdot}2$ is nece sary to close these results on the longitude arcs (*Vide* G. T. S. Volume XVIII, Appendix 8) giving corrected results of $-22''{\cdot}2$ and $-7''{\cdot}0$ respectively, on the Everest Spheroid. Expressed in terms of the latest spheroid (Helmert) a further quantity $5''\,6$ has to be added giving the final results—$16''{\cdot}6$ and—$1''{\cdot}4$, respectively. It is worthy of note that the station Retkamauk, situated on an island near the coast with open sea to the west and mountainous country to the east, shows only a very slight inland (eastward) deflection, whereas the station Yeponetaung which is 20 miles inland has a deflection of $16''{\cdot}6$ eastward. This is comparable with the seaward deflection found at coast stations in India, *e.g.*, Madras, Mangalore.

ASTRONOMICAL AND PENDULUM OPERATIONS.

No Astronomical or Pendulum Observations beyond those mentioned under " triangulation " were made during the year 1915-16, as, owing to the War, no officer was available to undertake them.

LEVELLING OPERATIONS.

Owing to the War, the field strength of this party was reduced from six to four levelling detachments.

The out-turn of work amounted to 822 miles of "fore and back double levelling of precision" as detailed below.

(*a*) *In the Punjab.*

(*i*) From Ambāla *viá* Karnāl to Sīnghū along the Grand Trunk Road. This forms part of the line which was carried on to Delhi.

(*ii*) From Jhang *viá* Fāzilka, Mandi Dabwāli, Sirsa, Hissār and Rohtak to Bahādurgarh by road, crossing the Sutlej and Rāvi rivers *en route*. This line was carried on to Delhi.

The above lines traverse numerous canals and large irrigated tracts in this province and will furnish additional data for irrigation and other purposes.

(*iii*) A branch-line from Fāzilka to Amruka, which was continued to Sadikganj (Bahāwalpur State), was run in order to strengthen the connection of the Standard bench-mark at Sadikganj. It was originally connected in 1909-10 with only one old bench-mark. This connection was considered unsatisfactory, and was rejected.

(*b*) *In the Delhi Province.*

(*i*) From Sīnghū along the Grand Trunk Road to Delhi. This is part of the line which runs from Ambāla *viá* Karnāl.

(*ii*) From Bahādurgarh to Delhi along the Rohtak-Delhi road. This line is a continuation of that from Jhang *viá* Fāzilka, Hissār and Rohtak to Bahādurgarh.

The lines in this province and in the Punjab, complete four new circuits, the closing errors of which have not as yet been determined as the computations have not been completed.

(*c*) *In the United Provinces.*

Revision of the following lines :—

(*i*) From Somna to Alīgarh along the Grand Trunk Road and thence along the main road to Agra.

(*ii*) From Agra to the Bāngangā river. This line was carried on to Gwalior *viá* Dholpur along the Agra-Bombay Trunk road.

The above lines were originally levelled in 1861-62.

(*iii*) From Lucknow *viá* Unao to Cawnpore by road. This line was originally levelled in 1868-69.

In 1913-14, the new system of "fore and back double levelling of precision" on the lines laid down in the resolution passed at the International Geodetic Conference of 1912, was first adopted and has since been employed.

The following table gives the results of the various lines which have been levelled on this new system, the computations of which have been completed. It will be seen that the results of the probable accidental and systematic errors are well within the prescribed limits as given in the resolution passed at the above mentioned Conference for "Levelling of High Precision."

Table showing (*i*) the probable accidental error, and (*ii*) the probable systematic error, calculated according to the following formulæ taken from Departmental Paper No. 6 of 1914 :—

$$(i)\ \eta_r^2 = \frac{1}{9}\left[\frac{\Sigma\,\Delta^2}{\Sigma\,L} - \frac{\Sigma\gamma^2}{(\Sigma\,L)^2}.\ \Sigma\frac{S}{L}\right]$$

$$(ii)\ \sigma_r^2 = \frac{1}{9\Sigma\,L}\ \Sigma\frac{S^2}{L}$$

η_r, is the probable accidental error in the case of a group of lines, whether forming a closed mesh or not ;

σ_r, is the probable systematic error in the case of group of lines not forming a network ;

L, is the length of an isolated line, or a side of polygonal mesh in the case of a network ;

Σ L, is the total length of a group of lines or of the network ;

Δ, is the discordance of the results of the fore and back levelling found between two consecutive bench-marks ;

γ, is the distance between these two bench-marks ;

S, is the total systematic discordance found for a complete line or for the side of a mesh, between the results of the fore and back levelling.

Lines.	Length.	PROBABLE ACCIDENTAL ERROR.	PROBABLE SYSTEMATIC ERROR.
		±0·00416 foot per mile.*	±0·00106 foot per mile.*
	Miles	Foot per mile.	Foot per mile.
Jacobābād to Quetta	207·231	±0·0037	±0·0001
Benares to Barākar with branch line to Belsar Lock.	312·872	±0·0024	±0·0002
Meerut *viâ* Morādābād and Bareilly to Hāthras .	243·737	±0·0024	±0·0002
Multān to Bahāwalpur	59·244	±0·0023	±0·0004
Raichūr *viâ* Bāgalkot to Bijāpur . .	170·380	±0·0028	±0·0004
Bellary to Gooty	57·610	±0·0023	±0·0010

* Limit which must not be exceeded in "Levelling of High Precision."

TIDAL OPERATIONS.

Tidal registrations by means of self-registering gauges have been carried out during the year at the ports of Aden, Karāchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

With the exception of a few minor interruptions in the registration of the tides at Aden and Prince's Dock owing to the stoppage of the driving clocks, the tide-gauges at all the observatories have worked satisfactorily.

All the tidal observatories were inspected during the year and the instruments were thoroughly overhauled and cleaned and put in working order.

On comparing the predictions of times and heights of high and low water for the year 1915 with the corresponding actual readings, the predictions of times at Aden, Madras and Port Blair and those of heights at Kidderpore and Karāchi were found to have slightly improved since the year 1914. The predictions at the other stations were practically of the same standard of accuracy as those of the year 1914.

In addition to the automatic tidal registrations at the nine stations named above, personal observations of high and low water were taken during daylight on tide-poles at Bhaunagar, Chittagong and Akyab. The object of these observations was to test the accuracy of the tidal predictions for these ports. The automatic tidal registrations on which the predictions were based were stopped many years ago.

OPERATIONS AT DEHRA DUN.

BY

J. de GRAAFF HUNTER, M.A.

In last year's report reference was made to an integrating machine to calculate automatically the effect of topography (or of any irregularities of crustal density) on the direction of the plumb line. This instrument has recently been completed in the Dehra workshops, considerable time having been spent in improving the details of design, so as to obtain satisfactory working. Owing to press of other work and shortage of suitable officers, no application of the machine has been made as yet : nor does there appear to be much prospect of such work being taken up under present conditions.

An investigation into the strength and probable error of triangulation has been carried out and some useful results have already been obtained. In any discussion of plumb line deviation, it is desirable to know the probable error of the azimuths and co-ordinates (latitude and longitude) brought up by triangulation. By means of a quantity M (depending on the triangular error, mean length of sides and nature of the figures of a triangulation series, *vide*

Records of the Survey of India, Vol. IX) it has been possible to find simple formulæ expressing the probable error of side, azimuth, latitude and longitude developed in any triangulation system, before closure of circuits and closure on base lines has been effected. Special cases of closure have also been worked out, but the general question of probable error after adjustment of a network as a whole, is still under investigation. The formulæ for probable error before adjustment of circuit errors have been applied to the triangulation of India and the results show a satisfactory accordance with the actual closing errors which have been found. They have also been made use of in discussing the results of the revisionary triangulation executed to discover whether any general horizontal movements were caused by the Shillong earthquake of 1897 : the preliminary conclusion being that the movements, if any, were too small to be shown with certainty by the revisionary triangulation.

The formulæ show that the probable closing errors in latitude and longitude, or better, in northing and easting, increase, not as the square root of the linear dimensions, as might at first sight be imagined—such is the case in the probable error of height along a line of levelling—but as the three-halves power of the linear dimensions. This shows the necessity for measuring extra base lines from time to time and also of forming Laplace Stations. That this was not clearly recognised earlier, is indicated by the fact that no Laplace Stations were brought into the grinding of the Indian triangulation, though 7 additional base lines were. The network of electro-telegraphic longitudes was not completed when the triangulation was adjusted.

An exact analogy has been found between a network of triangulation and a somewhat similar mechanical framework composed of members whose strength is related to the probable error of the angles of the triangulation. The most probable adjustment of the former to effect a closing correspond with the natural strains set up in the latter to effect a similar closing. The corresponding underlying principles are, in one, that the weighted sum of the squares of the adjustments is a minimum and, in the other, that the sum of the squares of the various strains multiplied by suitable factors (the products being equivalent to the work done in setting up these strains) is a minimum. This is equivalent to the principle of least work.

The analogy enables certain theorems in the adjustment of observations to be easily seen at once. It is of fairly general application and is not only useful for consideration of triangulation adjustments. The analogy gives a number of suggestions as to methods by which triangulation may be adjusted in accordance with the principles of least squares and it also in some cases makes it possible to see whether some deviation from the rigid theory may be introduced for the sake of simplicity without seriously vitiating the results.

Triangulation Pamphlets.—Good progress has been made with publication of triangulation data, pamphlets (not including modern minor triangulation) for 160 degree sheets having been printed during the year.

BOTANY.

I.—BOTANICAL SURVEY.

BY

MAJOR A. T. GAGE, I.M.S.,

Director, Botanical Survey of India.

Eastern India.—The usual collections of seeds of Alpine species of the Sikkim Himalaya for distribution to botanical gardens in temperate regions were made by Lepcha collectors under the supervision of Mr. G. H. Cave of the Lloyd Botanic Garden, Darjeeling. Mr. R. E. Cooper on behalf of an English firm of nurserymen toured through a considerable part of Bhutan, and has written for the Records of the Botanical Survey a general account of the vegetation of the areas traversed by him. The Primulas of the Eastern Himalaya have been under study by Professor Balfour of Edinburgh University and Mr. W. W. Smith of the Royal Botanic Garden, Edinburgh. New species from this region described by them are *P. Calderiana*, *P. Gageana*, *P. indobella*, *P. melichlora*, *P. prionites*, *P. Waddellii*.

From the same region Dr. Stapf of the Royal Botanic Gardens, Kew, has described a new species of *Sarcococca* (*S. Wallichii*) originally collected by Wallich nearly a century ago. M. Raymond Hamet has described two new species of Sedum (*S. Bourieri* and *S. Cretini*), and Mr. W. G. Craib a new species of Acacia, (*A. Gageana*).

In Assam, Rai Upendranath Kanjilal Bahadur has continued his exploration and study of the vegetation of that province and has presented many duplicates to the Botanical Survey. His collections have yielded a new species of *Bassia* (*B. butyraceoides* Scott). In the Spring and in the Autumn Dr. H. G. Carter, Economic Botanist to the Botanical Survey explored the district of Lakhimpur in the extreme north-east of Assam, paying particular attention to the cultivated plants. Dr. Carter's collections and notes are now being worked out. From Tipperah Mr. P. M. Debburman, Assistant for Systematic work, contributed a large collection of specimens.

In Burma Mr. A. Rodger, Forest Research Officer, has materially aided the Botanical Survey by presenting duplicates of his extensive collections. A new genus called *Beesia* has been founded by Professor Balfour and Mr. W. W. Smith to accommodate a new species, *Beesia cordata* of the family Ranunculaceæ, a herbaceous plant discovered by Mr. F. Kingdon Ward in Northern Burma near the Chinese frontier and in Yunnan. The following new species from Burma have also been published during the year by the

authors whose names are attached to them:—RANUNCULACEÆ—*Clematis burmanica* Lace, *C. Craibiana* Lace; BERBERIDACEÆ—*Mahonia siamensis* Takeda; POLYGALACEÆ—*Polygala palustris* Lace, *P. pellucida* Lace; STERCULIACEÆ—*Buettneria integrifolia* Lace; CELASTRINEÆ—*Euonymus longipes* Lace; ANACARDIACEÆ—*Allospondias laxiflora* Lace; LEGUMINOSÆ—*Uraria barbata* Lace; *Mucuna Collettii* Lace, *Pueraria Lacei* Craib, *Eriosema pilosum* Lace, *Bauhinia sericea* Lace, *Acacia insuavis* Lace, *Acacia macrocephala* Lace, *Albizzia crassiramea* Lace; MELASTOMACEÆ—*Oxyspora rupicola* Lace; CAPRIFOLIACEÆ—*Lonicera Buchananii* Lace; ERICACEÆ—*Rhododendron carneum* Hutchinson; PRIMULACEÆ—*Primula seclusa* Balf. f. and Forrest, *P. meiantha* Balf. f. and W. W. Smith, *P. coryphœa*, *P. fragilis* and *P. sciophila* all Balf f. and Ward; EBENACEÆ—*Diospyros glandulosa* Lace; ASCLEPIADACEÆ—*Marsdenia carnosa* Lace; GENTIANACEÆ—*Swertia kachinensis* Lace; LENTIBULARIACEÆ—*Utricularia brevilabris*, *U. Rogersiana* and *U. suberecta* all by Lace; LILIACEÆ—*Sansevieria burmanica* N. E. Brown.

Mr. W. G. Craib records the finding of *Anemone obtusiloba* Don on Mount Victoria in the Arakan Yomah, which extends the distribution of this species from its hitherto known area considerably southwards.

The same botanist has cleared up the confusion whereby two distinct species were included under *Orophea polycarpa* A. DC. and two under *Artabotrys burmanicus* A. DC. and has made two new combinations *Orophea monosperma* Craib and *Artabotrys uniflora* Craib to distinguish the species separated out.

In Bengal the late Mr. M. S. Ramaswami studied the oecology of the acquatic plants of Bengal and contributed the results of his observations to the third Indian Science Congress. Mr. C. C. Calder has recorded an interesting introduction to Bengal in *Petiveria alliacea* L. (*Phytolaccaceæ*) which shows a tendency to spread with undesirable freedom. Mr. J. C. Carroll of the Imperial Forest Service contributed an excellent collection of the more characteristic swamp plants of the Sunderbuns. The collection contained a specimen of *Bruguiera parviflora* W. and A. a species which has only once previously been reported—by Goodlad in 1796—from the Sunderbuns.

Western India.—The final part of Father Blatter's Flora of Aden was published during the year, containing descriptions of the genera and species from *Hydrocharitaceæ* to *Lichenes*, and a comprehensive bibliography. Messrs. L. J. Sedgwick, I.C.S., and W. T. Saxton, I.E.S., have studied the vegetation of Northern Gujarat and have written an account of its various features with a list of the Flora of the district. This account will be published as soon as opportunity permits in the Records of the Botanical Survey. Mr. H. M. Chibber has published a useful list of the families and genera of Bombay plants, with derivation of the names.

Northern India.—While engaged during 1913 in triangulation work in the Taghdumbash Pamir, Lieutenant K. Mason, R.E., and Captain R. W. G. Hingston, I.M.S., collected specimens of every plant noticed. The collection

was worked out in the Calcutta Herbarium by the late Mr. M. S. Ramaswami and forms the subject of Chapter IX of Vol. VI of the Records of the Survey of India. In all 44 species representing 35 genera and 18 natural orders were collected. The bulk of the scanty vegetation consisted of dwarf herbaceous perennials with bulky root stocks and often strong resistant seed capsules. The predominant orders were *Compositæ, Cruciferæ, Leguminosæ* and *Gramineæ*.

Mr. S. R. Kashyap has continued his studies of the Liverworts of the N. W. Himalayas and the Punjab and has described the following new species:—*Fimbriaria pathankotensis, F. mussuriensis, Mindal pangiensis, Sauchia spongiosa, Athalmia dioica, Riccia* (*Ricciella*) *robusta, R. cruciata, R. pathankotensis, R. himalayensis, R. sanguinea.*

The following new species of flowering plants from the N. W Himalayas have been published during the year :—CRASSULACEÆ—*Sedum Seellmanni* Hamet; PRIMULACEÆ—*Primula glandulifera* Balf. f. and W. W. Smith, *P. Harrissii* Watt, *P. rhodantha* Balf. f. and W. W. Smith, *P. rosiflora*, Balf. f. and W. W. Smith, *P. taupoda* Balf. f. and W. W. Smith.

Central India.—Mr. H. H. Haines of the Imperial Forest Service has published a Key to the Forest Flora of the Southern Circle.

Southern India.—Collections were made in various districts of the Madras Presidency by the Government Lecturing Botanist who also prepared a note on the flora and a list of the plants of the Tinnivelly District for the District Gazetteer, and made out a list of the plants in and around Taliparamba. Collections made in the Anamalai Hills by Mr. C. E. C. Fischer of the Imperial Forest Department, in Madura by the Rev. Father Van Maldaren and in Travancore by Mr. C. C. Calder and the late Mr. Ramaswami have been worked out as opportunity offered during the year.

The first part of the Flora of the Presidency of Madras by Mr. J. S. Gamble, F.R.S., C.I.E., appeared during the year, consisting of 200 pages devoted to the genera and species of the families from *Ranunculaceæ* to *Aquifoliaceæ*. Mr. F. P. Fyson has published an account in two volumes—one of letter press and another of plates—of the Flora of the Nilgiri and Pulney Hill tops. Nearly 500 species are described, and there are notes of interest on floral mechanism and economic properties.

The following new species from Southern India have been published during the year :—RUTACEÆ—*Acronychia Barberi* Gamble ; OCHNACEÆ—*Ochna Beddomei* Gamble ; MELIACEÆ—*Aglaia Barberi* Gamble, *A. Bourdillonii* Gamble, *A. canarensis* Gamble ; CELASTRACEÆ—*Glyptopetalum Lawsonii* Gamble, *Microtropis Stocksii* Gamble ; HIPPOCRATEACEÆ—*Hippocratea Bourdillonii* Gamble, *Salacia malabarica* Gamble, *S. Beddomei* Gamble, *S. Talbotii* Gamble; RHAMNACEÆ—*Ventilago Goughii* Gamble, *V. lanceolata* Gamble ; STAPHYLEACEÆ—*Turpinia malabarica* Gamble ; ANACARDIACEÆ— *Buchanania Barberi* Gamble ; RUBIACEÆ—*Anotis longiflora* Hutchinson ; COMPOSITÆ—*Vernonia Ramaswamii* Hutchinson.

Dr. J. C. Willis has published a list of further corrections and additions to Trimen's " Flora of Ceylon " and a paper on the evolution of species in Ceylon with reference to the dying out of species.

Mr. H. N. Dixon has published a list of the species of Ceylonese mosses collected by the Rev. C. H. Binstead in 1913. Four new species are described :—*Dicranodontium sparsum*, *Fissidens aberrans*, *Macromitrium assimile*, *Bryum ceylonense*.

General.—Messrs. Burns and Prayag have described the grafting of mango infloresences. Mr. M. O. P. Iyengar has studied the defoliation of some Madras trees and has explained the shedding of old leaves, the rapidly ensuing growth of new leaves at the commencement of the hot season, and the influence of salt breezes.

Mr. N. E. Brown formerly of the staff of Kew has published a Monograph of the genus *Sansevieria* with a key to the species.

Mr. S. C. Banerji has published a note on the strangling of a palm by a fig.

The Rev. Father E. Blatter published during the year Part XV—devoted to the genus *Areca*—of his Palms of British India and Ceylon.

Mr. T. Ekambaram has published the results of an interesting study of the irritability of the bladders of *Utricularia*.

The writer has published a short paper on photographic methods of registering the size of plants. The development of the flowers of *Diospyros Kaki* has formed the subject of a paper by Kono Yasui.

Additions to the Indian Flora.—Between sixty and seventy species of flowering plants have been added during the year to the known Flora of India and Burma.

List of Papers.

BALFOUR, I. B. . . New species of Primula. (*Notes from Roy. Bot. Gard. Edinburgh, ix, No. 41, (1915), pp. 1-62.*)

BALFOUR, I. B. AND SMITH, W. W. *Beesia*, a new genus of *Ranunculaceæ* from Burma and Yunnan. (*Notes from Roy. Bot. Gard. Edinburgh, ix, No. 41, (1915), pp. 63-64—with 1 plate.*)

BANERJI, S. C. . . A Botanical Curio. (*Proc. Asiat. Soc. Beng.*)

BLATTER, E. . . The Palms of British India and Ceylon, Part XV. (*Journ. Bomb. Nat. Hist. Soc. xxiv, 329-340 with 3 plates.*)

BROWN, N. E. . . *Sansevieria* (*Kew Bull., 1915, No. 5, pp. 185-261*).

BURNS, W. & PRAYAG, S. H. Grafting the Mango infloresence. (*Journ. Asiat. Soc. Beng. xi, 7-8 with 3 plates.*)

CRAIB, W. G. . . *Mimosa caesia* and *M. Intsia*. (*Kew Bull., 1915, No. 9, pp. 407-410.*)

CRAIB, W. G. . .	*Orophea polycarpa* and *Artabotrys burmanicus*. (*Kew Bull. 1915, No. 10, pp. 433-435.*)
" . .	*Ornithobœa Lacei*. (*Bot. Mag., 1915, tab. 8627.*)
" . .	*Anemone obtusiloba* Don forma *patula*. (*Bot. Mag., 1915, tab. 8636.*)
CHIBBER, H. M. .	A list of the Natural Orders and Genera of Bombay Plants with Derivations of the names. (*Journ. Bomb. Nat. Hist. Soc. xxiv, 244-290.*)
DIXON, H. N. . .	Ceylonese mosses. (*Journ. Bot. liii, 257-267 with 1 plate.*)
DUNN, S. T. .	*Millettia subpalmata*. (*Hook. Ic. Plant, 5th Ser. i, tab. 3039.*)
EKAMBARAM, T. . .	Irritability of the bladders in *Utricularia*. (*Agric. Journ. Ind. Special Indian Science Congress Number pp. 72-79.*)
FYSON, P. F. . .	Note on the Flora of the South Indian Highlands. (*Journ. Asiat. Soc. Beng. xi, 27-28.*)
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BOTANY.

II.—ECONOMIC BOTANY.

Part I.—Agricultural Botany

BY

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In a previous report attention was drawn to the fact that the output in Agricultural Botany was small in consideration of the numbers of workers in the field, and that this was apparently caused by the Botanists having dual duties. In almost every case the whole attention of the Provincial Specialists was being devoted to the preparation of new courses of lectures for agricultural students. That this is a serious handicap to research is at once obvious on comparing the annual output of Botanists engaged in teaching with that of the few who are free from this work. But it is also to be noted that the improvement then foreshadowed has been maintained and, in almost every province, new lines are being opened up—presumably because the teaching has become stereotyped and is no longer so severe a tax as it was when the courses of lectures were under preparation. On the other hand the work accomplished by the agricultural district officers has steadily increased in importance, an additional argument, if any were needed, for a further divorce between teaching and research among the specialists on whose work these advances are in the main dependent. In the present year there have been special setbacks, in one Province because of increased educational responsibility on the part of the Botanist and in several others because of shortness of men owing to the war.

In the previous report referred to, two lines of work were contrasted—that along the old lines of plant breeding and the creation of new varieties by Mendelian studies, and the time has come when we can in some sort take stock of our advances in these two directions. It was pointed out that one of the most striking characters of Indian field crops, grown for centuries undisturbed under the same conditions, is the enormous extent of admixture of varieties in almost every direction and that, in many cases, the mere separation of the various types by pure line cultures has led to great agricultural progress. On the other hand it was surmised that the field opening up

for the creation of new varieties by Mendelian work was a vast one full of promise. Our experience, after three years' further work, has to some extent modified this forecast. While the prosecution of pure line cultures has almost everywhere resulted in distinct advances, the difficulties surrounding the Mendelian work have steadily increased. It is not easy indeed to put one's finger on any definite improvement in the field emanating from pure Mendelian work. This aspect of the question arrests attention, and has been very clearly stated by Mrs. Howard, one of our leading workers in this subject, in a recent paper. She writes " Some years have now elapsed since Mendelism first came into prominence, and it may be of interest to see how far the early anticipations have been realised in what is, after all, the simplest and most promising domain—the improvement of crops." After describing the way in which, by combining advantageous characters in one plant, enormous gains would accrue to Indian agriculture, she writes " It must now be confessed that the results hitherto achieved have fallen below expectation and the number of cases in which direct economic benefit has been derived from the application of Mendel's law are few". The difficulties of the work are clearly laid out, including not only enormous labour but an insight on the part of the experimenter which can rarely be met with. " The successful investigator must steer between the Scylla of throwing away too much and the Charybdis of being overwhelmed by his material. Hitherto the characters studied by Mendelists are economically the least important, such as colour, markings, hairiness, while quality, immunity to disease, size of organs, etc., have hardly been touched." She concludes " The application of the principles of Mendelism can shorten the work of improvement and render it more certain than in the old days but it cannot accomplish the whole and, for the final stages, recourse must still be had to the older methods of selection. Mendelism can guide us for a certain distance on the way but it cannot, at present, by itself take us to the goal." In fact, we may be justified in agreeing with an exponent of Mendelism that the value of research in genetics is to be judged rather by its contribution to knowledge than by the aid given to the practical breeder.

It is obvious from the foregoing that it will be as a rule futile for specialists with the dual duties of teaching and research to expect much progress along this line of work. On the other hand, pure line breeding is in itself of so simple a nature that it is open not only to the specialists in the subject but to every one of the agricultural members of the department who has the time and opportunity to carry it out. But the systematic collection of the varieties of each crop is a necessary preliminary to such work. This is being now done to a very large extent in every Province. But the work needs organisation and it is not too much to say that mere Provincial work is insufficient. This is clearly brought out in the recent collections made by the Howards of mustard and gram varieties, where the most suitable types are often collected far from the place of experiment. A comprehensive survey of Indian crops is needed, with a fully equipped herbarium with land attached wherein to test the varieties

collected. Many of these have been proved by the Howards to be hybrids, and the relative purity of varieties grown in different parts would be one of the main pieces of work in any such survey, work which would be greatly assisted by the application of Mendelian principles.

But the institution of a survey of plants used in agriculture is not a matter lightly to be entertained. For such a survey to be in any way complete, a staff would be required greatly in excess of that employed in the existing Botanical Survey, besides many years of work. Owing to the presence of a machinery in the revenue inspectors and district officers, collections of cultivated plants have been made at various centres for many years. But, in the absence of co-ordination or leisure, most of the knowledge thus gained has been dissipated and lost. Examples are not difficult to quote. While the collections of sugarcanes at Gurdaspur, Sabour and Coimbatore have been eminently useful in gaining a knowledge of Indian varieties, those made in the past in Bengal and at present in Bombay, though very thorough and extensive are little likely to be utilised. It is all a matter of convenience and chance whether a collection, made by the enthusiastic work of individual officers shall be of more than passing interest. Sorghum perhaps gives us the best examples of wasted effort. Great collections have been made from time to time in various parts of Madras and grown in separate plots, but comparatively little knowledge has been added by these. Large collections have also been made and forwarded to the Reporter of Economic Products and these have formed the basis of a complicated classification. But, in the absence of a study of the genetic composition of the material, this classification has broken down. When indeed we view the possibility of a paddy or Sorghum survey, the task seems to be well nigh impossible. Mere herbarium work is out of the question. It would also be futile to attempt to collect these varieties in one place, for instance Pusa. The idea of geographical regions will have to be developed as to where such collections should be placed and tested. It would be as idle to collect paddies and cottons at Pusa as to make Madras the headquarters of, say, mustard, for in all cases actual growth in comparative plots and genetic study will have to form the basis of classification. The best temporary expedient that occurs to us is for a fully trained systematist to be placed in charge of such work and for him to act as consultant to the Provincial officers engaged in the survey of particular crops. Where collections have been made and it is not in the power of local officers to deal with them, his help would be available and much painstaking labour might thus be rendered fruitful, instead of being rendered useless by sheer inability to deal with the collections.

In the following pages an attempt has been made to deal with progress in agricultural botany in India in all directions, but it must be confessed that the record is very incomplete, and an apology is tendered to those workers who have inadvertantly been passed over.

Green Manuring.—This important subject has received marked attention during the year. Perhaps the most important paper on green manuring

as applied to crops is that of Dobbs, issued as a Pusa bulletin. After a discussion on the general theory, the practice is considered with special respect to India's needs, "essentially a country of arable and forests" and with remarkably poor nitrogen content in the soil, and local practices are summarised. The early experiments at Cawnpore, Dumraon and Nagpur are discussed and the early practice in the planting districts somewhat fully treated. The subject matter as regards field crops is divided into the following sections, rice, tobacco and other valuable cold weather crops, jute, sugarcane and garden crops, irrigated crops. In the first of these a great mass of information is collected regarding work in Madras, largely with the help of quotations from reports. The tobacco work is chiefly that done in Bihar. A short section at the close deals with the scientific work thus far accomplished and contains references to the work of the Howards on tobacco, Hutchinson on soil biology, Meggitt on acid soils and Harrison on soil gases. It is inevitable that, in the absence of personal knowledge, many local practices have been omitted, and it is a question whether a summary of these might not be of value in throwing light on the peculiar circumstances of many tracts. But the compilation is none the less valuable in bringing a number of detached observations and experiments into a collected form. The application of green manuring to the reclamation of alkali land has not apparently been included. This is an aspect of the subject which is becoming of increasing importance and there are many local methods connected with it in various parts of the country.

Allan has dealt somewhat fully with the green manuring of the Central Provinces, including a survey of the local practices and a study of the long-drawn-out experiments at Nagpur. He summarises and compares the value of the various methods adopted, from the carting of leafy substances grown elsewhere and the turning in of weeds, to the actual growing of crops for inversion either whole or after feeding off to stock. An analysis of two series of experiments at Nagpur, for 10 and 20 years respectively, shows a remarkable correlation between the amount of rainfall in the interval between ploughing in the green manuring crop and the sowing of wheat, and the subsequent amount of grain harvested. This does not agree with Evans's observations at Hoshangabad, where the soil cannot usually be sufficiently dried before inversion, and the advantages of green manuring are more than counterbalanced by the deleterious effect on the physical character of the soil. Allan concludes that the minimum amount of rainfall required for dry grown wheat in the interval between ploughing in and sowing is 12″, and that, in tracts where the the total monsoon rainfall is under 35,″ the practice of green manuring dry wheat is out of the question.

Green manuring is receiving a great deal of attention in planting districts. Hope draws attention to the facts that it should not be applied to rich land, as the fixation of nitrogen there is small, that, from analyses, the amount of nitrogen is seen to be vastly greater in the leaves than in the roots, and that full advantage cannot be obtained of this unless the leaves are fully decayed.

During the current year as many as forty different green manuring plants have been tested as to their comparative value in tea estates. Of the importations, *Desmodium tortuosum* deserves special attention. It was originally obtained from Queensland, resists drought, grows well through the cold weather without attention, gives a heavy yield and, on the whole, promises well as a green manuring crop. A remarkable bean collected from Nowgong is also worthy of attention. It is a perennial climber and its growth is so vigorous as to choke all the crops, including even trees. It is thus likely to be of use in keeping down the weeds of areas cleared for tea planting and also to kill out abandoned tea estates. Hope points out that phosphatic manures can be made use of in increasing the growth of the crop to be dug in. It was found that basic slag and superphosphate gave better results than any other form tried. This use of phosphates is in agreement with Allan's results in Central Provinces, where green manuring before paddy is under special difficulties. Anstead, working in South India, discusses the value of *dadap* in tea plantations and has worked out the proper time and number of loppings as well as the way in which these are to be dealt with, the first to be used as a mulch on the ground in the beginning of the hot weather, followed by a later lopping in September to be dug in. After four years the trees are to be removed and new ones planted in the intervening rows, thus ensuring continuity in the practice. A large number of green manuring crops have been analysed, including the non-nitrogenous *Peristrophe bicalyculata* which forms excellent cover, seeds within the year and sows itself and contains a considerable amount of nitrogen. This use of non-nitrogenous plants must not be lost sight of, provided that they contain a sufficient amount of nitrogen. The usefulness of plants other than the *Leguminosæ* has to a large extent been lost sight of during recent years, owing no doubt to a mistaken notion that the nodules of the latter add nitrogen to the soil. Many cases could doubtless be found where a non-leguminous crop would give better results. The nitrogen content of *Peristrophe bicalyculata* is given by Anstead as superior to that contained in *Tephrosia tinctoria*. Another instance is seen in the digging in of *Vernonia* as practised in the Central Provinces.

The spread of green manuring in Madras continues. Thomas reports that the amount of seed of *Kolinji*, (*Tephrosia tinctoria*) distributed during the past three years in the Periyar tract has steadily increased, the figures recorded being 1913-14, 42,000 lbs., 1914-15, 62,375 lbs., 1915-16, 75,946 lbs. The practice has now been introduced into the Tanjore delta where, during the past year, 11,530 lbs. of *Kolinji* and 4,805 lbs. of *Daincha* have been sold. The cultivators appear to be well aware of the danger of irrigating the green manuring crop in the dry weather.

The Howards have demonstrated the importance of *shaftal* (*Trifolium resupinata*, a common crop around Peshawar) as a preparation of the land for wheat in the Quetta valley, the plants being dug in after three cuttings and the collection of seed in June. This will be referred to elsewhere.

Harrison in Madras has dealt with the relations of green manuring to swamp-irrigated paddy. He points out that most of the nitrogen obtained from digging in the green manuring crop is dissipated, and that the value of the practice is therefore to be sought more in the physical amelioration of the soil than in the addition of nitrogen as a manure.

Weeds in Cultivated Land.—Graham has done useful work in preparing lists (1) of wild plants and (2) of grasses and sedges in the Nagpur and Telinkere farms of the Central Provinces (1911-13). The subject forms a natural link between that of green dressing and fodders, common weeds having been shown to be useful in both these respects. The presence of *Kolinji* (*Tephrosia tinctoria*), growing naturally in South India, has led to a great stimulus to green manuring in that region. In other places it is the usual practice to cart leaves of trees and weeds for long distances to incorporate in the soil. In tracts with abundant rainfall the digging in of weeds is a natural form of green manuring, which is of obvious value in improving the physical texture of the soil. This practice, indeed, takes the place of green manuring where that would be impossible. For instance, in Burma where the onset of the rains is so sudden and heavy that *daincha* and *sann hemp* cannot be sown, their place is taken by the instantaneous growth of masses of weeds which are dug in before transplanting paddy. The digging in of the weeds peculiar to paddy fields is a common practice in many other places—where the rotation may be described as one of paddy and weeds—and is undoubtedly beneficial in that the weeds do not foul the land under crop and do not germinate until it dries after the last paddy has been harvested. Many planters encourage different weeds for covering the ground and digging in afterwards, and reference has been made to the use of green dressing with *Vernonia* in the Central Provinces paddy fields and *Peristrophe bicalculata* in Coorg. Anstead has made considerable progress by encouraging the growth of leguminous weeds on tea estates. In yet other places the weeds are collected and placed in pits, to be spread on the ground as leaf mould when thoroughly rotted, a common practice in most gardens. But in spite of all this usefulness, the weeding of crops is a serious item of expense and the toll taken in badly kept land makes all the difference between good and bad agriculture.

Rangachari has studied the weeds of the Coimbatore Central Farm during the past three years. This study was undertaken with the idea of determining the weed flora, the relationship between the soil and its vegetation, the dominancy of special forms, and special features as to distribution of seeds. 248 species have been collected and examined, belonging to 149 genera and 37 natural orders. The following principal ones are arranged in order of numbers of species contained :—*Gramineæ*, *Leguminosæ*, *Compositæ*, *Malvaceæ*, *Euphorbiaceæ*, *Acanthaceæ*. Dominant species are *Cynodon dactylon*, *Cyperus rotundus*, *Phyllanthus maderaspatensis*, *Corchorus trilocularis*, *Leucas aspera* and *Tridax procumbens*, all of them occurring on any soil. No definite relation

has been determined between loamy soils and the weeds growing on them, but certain species are found to be quite characteristic of black cotton soil. These are *Aristolochia bracteata, Panicum Isachne, Momordica Cymbalaria, Chrozophora plicata, Alysicarpus longifolius* and *Heliotropium marifolium.* A handbook is being prepared, for which about 50 species have already been fully described, with illustrations. Such work is undoubtedly useful, for, to treat weeds properly, it is necessary to know their relative powers of reproduction and the amount of damage that the different species can do. It may be noted here that, in the progress of the Botanical survey of the Madras Presidency some years ago by the writer, a very distinct flora was seen to occur in paddy fields, and that this flora was independent of the geographical and climatal limitations imposed on ordinary plants.

The seed testing section of the Bombay Agricultural Department has issued a bulletin analysing the weed seeds in the various crops of Sholapur district. This is the sixth bulletin of the series, former numbers having dealt with the Broach, Amednagar and Poona districts. The authors conclude that the seed supply is capable of considerable improvement and that this may be effected by better storage, which would protect the seeds from weevil attack, the introduction of sieves by which weed seeds would be automatically separated and by removing the necessity of sowing seed intended for consumption. A classified list is appended of the various species whose seeds are found mixed in the cultivators' seed supply.

Robertson Brown draws attention to the fact that *berseem* seed obtained from Egypt is almost invariably mixed with that of chicory (*Chicorium Intybus*). "It behoves those that grow *berseem* in India to weed out chicory rigorously, especially where *berseem* is permitted to ripen seed, for this deep-rooted perennial herb, like most of the *Compositæ*, produces a great quantity of seeds which are readily dispersed. When it is established, chicory is even more difficult and expensive to eradicate than *Carthamus oxyacantha*."

A growth of weeds in irrigation canals may be referred to here. Burns was invited to examine the weed growth of the Godavari and Pravara canals in Bombay and found that the chief offender was *Potamogeton perfoliatus*, this plant causing serious impediment in the flow of water. He carefully studied the life history and mode of reproduction with a view to check its growth and prevent its further spread. Certain useful data have been obtained, and the whole question of the control of aquatic weeds in the canal is being worked out.

The introduction into Madras of the Water hyacinth (Eichhornia speciosa) has received considerable attention during recent years. A leaflet by Chadwick contains a warning and refers to its evil effects in parts of America. He points out that considerable inconvenience is already felt in Burma where the growth has become so dense that it is being cut in large masses and

dragged out to seas by steam tugs. It is doubtful if this pest can be long kept out of Madras tanks, considering how strong its hold is in many parts of Orissa and Bengal, but the warning extended in the leaflet is timely.

Fodders.—In spite of the importance of the subject, comparatively little attention appears to be paid to it by workers in the Agricultural Department. More attention is given in Bombay than elsewhere, and a number of papers have been published in various journals there. Mann and Ranade investigated the feeding value of four different grasses from the same locality which had a very different value in the eyes of the local cultivators. Chemical analyses showed comparatively little variation in the quantities of nutritious substances, which led them to conclude that the differences were due to the physical conditions of the grasses or to some of the proximate constituents. A careful study of the botanical characters showed that two of them had spiny fruits of different duration and sharpness, but this did not completely solve the problem.

A number of articles on fodders have appeared in the current numbers of the Poona Agricultural College Magazine indicating, the general interest of the Department in the subject. Descriptions are given of the commoner and more valuable grasses and xerophytic plants used in times of scarcity and the means to be adopted of increasing their value. The local knowledge of the chemical analyses, feeding value, modes of reproduction and distribution seems to be fairly full and the problem of improving the natural feeding grounds has received a good deal of attention. Burns, Bhidie, Kulkarne and Hanamante have described some 34 species of fodders, grasses and leguminous plants which grow wild, with illustrations, noting their respective yields, feeding value and response to cultivation. This is in the press and will be published as a bulletin of the Department.

In an appendix to the list of grasses and sedges at Nagpur already referred to, Plymen adds an interesting note on the feeding value of the fodder grasses. Analyses are given of (1) those considered good for fodder and (2) those esteemed principally for hay and (3) these are compared with a poor spear grass and a common leguminous weed. A further comparison is made between the local fodder grasses and the same species grown in Bombay, because of the prevalent belief that the latter are superior for feeding cattle. Judging by the analyses, the belief is justified in that "proteid, the most important constituent of the grasses is found in much greater proportion in the Bombay specimens, the same being true of mineral matter, excluding sand, whereas the proportion of crude fibre is greater in the local forms." From this it will appear that climate and soil have a marked effect on the relative feeding value of different fodders.

Rangachari has made a study of the fodder grasses of Nellore, one of the chief cattle-rearing centres in India. The most useful grasses have been

separated and notes prepared on them. But, however perfect our knowledge of the value and characters of fodder plants may become, this is only an indirect step towards improving the pastures. There are innumerable systems of grazing adopted in various parts of India and the following is quoted as possibly a useful example to be followed elsewhere. The system introduced into this tract is as follows. The right of grazing in the reserved areas is sold by auction annually, the lowest sum being four annas per acre. The purchasers are bound to graze only one bullock or two sheep for every 2 acres, to give preference to horned cattle over sheep, to graze only from November to June and to hold themselves personally responsible for illicit felling and goat trespass. The system appears to be working satisfactorily in the district.

Howard and Howard have investigated the possibility of increasing the fodder available for the military establishment in the Quetta valley, at the same time introducing a green manuring crop for the improvement of the wheat land. Lucerne was unsuitable because it occupies the ground for 5-6 years, and four other leguminous crops were tried *sulla* (*Hedysarum*) and three clovers, *berseem*, annual red clover and *shaftal*. The *sulla* was unable to withstand the cold, *berseem* gave too light a yield and red clover was too long in maturing. *Shaftal* (*Trifolium resupinatum*) was in all respects the best, yielding four good crops in the year, seeding freely in June and greatly improving the wheat land if dug in after the seed had been collected. The seeds should be sprouted before sowing and then spread on irrigation water under a light cover crop of maize or juar ; a light earth mulch is of great advantage in saving water, both on sowing and after removing the crop early in September. The yield in unmanured land was 60,000 lbs. per acre. It was successfully made into hay and the necessary precautions in such a dry climate have been carefully worked out. The samples of fodder have been much appreciated by the military authorities and abundant seed can be obtained from the botanical section.

Burt, experimenting with *teff grass* (*Eragrostis abyssinica*) at Cawnpore, obtained $1\frac{1}{2}$ tons of hay or 5-6 tons of green fodder from December to May, a time when fodder is scarce. It is important to obtain the right variety, as some of those experimented with were of comparatively little value, and this may account for conflicting reports regarding *teff* received from elsewhere.

Paddy.—This important crop is receiving increased attention, and a great step forward has been taken in Madras by the founding of a Paddy Breeding Station under Parnell, the Economic Botanist, at Coimbatore. Work on this crop in fact occupies almost the whole time in his section. " A survey of varieties of the Presidency is being made in co-operation with the District staff who are responsible for collecting the varieties and supplying first-hand information regarding their culture, etc. The varieties are grown on the Paddy Breeding Station where descriptions of the plant, paddy and rice are recorded. The investigation of the method of inheritance of various characters is receiving considerable attention. Many varietal characters of

a morphological nature have proved to be due to simple Mendelian factors as follows :—

——	*Dominant.*	*Recessive.*
1. Outer glumes	Short ($\frac{1}{4}$ — $\frac{1}{5}$ length of inner glumes).	Long (about equalling inner glumes).
2. Inner glumes	Green . . .	Golden.
3. Do.	Do. . . .	Dark blackish brown furrows.
4. Golden colouring and dark furrows of inner glumes.	Piebald . . .	Self colour.
5. Pulvinus (at base of leaf sheath) . Do. (at base of lamina) . Auricle	Dark purple. . .	No purple.
6. Outer epidermis of leaf sheath, extending to and including ligule.	Purple . . .	Do.
7. Leaf sheath and internode . .	Purple lined . .	No lining.
8. Outer and inner glumes . .	Purple . . .	No purple.
9. Stigma	Do. . . .	White.
10. Axil and inner surface of lower part of leaf sheath.	Do. . . .	Do.

Gametic reduplication occurs in the segregation of the factors concerned in Nos. 7-10. Coupling, either complete or of a very high degree, has been recorded between Nos. 7 and 8, as also between 9 and 10, and complete repulsion occurred between these two pairs of factors.

The following characters depend on the presence of two factors and give 3 : 1 or 9 : 7 ratios, according as segregation is taking place for one or both factors respectively :—

Full red colour of rice,

Black colour of inner glumes during ripening,

Power to produce purple pigment,

Long awns.

The following are some of the special economic characters under investigation :—Size and shape of grain, habit of plant, tillering power, duration of crop and scent of rice.

The amount of natural cross-fertilization in different parts of the Presidency has been estimated and found to vary from 0·1 per cent. to 3 per cent., according to the variety.

The improvement of local varieties by simple single-plant selections has been started on the Government farm at Manganallur in the Cauvery delta."

Harrison has continued his study of the soil gases in swamp paddy cultivation at Coimbatore. "The function of the organised film found upon the surface of paddy soil has been studied in greater detail, and a specific bacterium has been isolated which possesses the power of oxidizing the hydrogen of the soil gases to water. This has been described in a Memoir of the Department of Agriculture in India (Chemical Series, Volume IV, No. 4). Another bacterium which oxidizes marsh gas to carbon dioxide and water, has also been isolated and studied, but the results have not been published as yet. The importance of this bacterium lies in the facts, that the carbon dioxide thus produced is in turn decomposed by the green algae present in the film and that the oxygen thus liberated is utilized for root æration. This cycle results in the utilization of green manures and other organic matter for the better aeration of the paddy roots, leading to more healthy root development and better cropping.

The investigation relating to the paddy soil conditions was however mainly directed to elucidating the source of the gaseous nitrogen of the soil gases and the results are now in the press. Briefly, it has been shown that much of the nitrogen is produced by the decomposition of the organic matter present in the soil, and, in fact, a large proportion of the nitrogen of green manure appears to be dissipated in this way and rendered vaueless for manurial purposes. Green manures must not therefore be considered as direct manures, but rather as manures which owe their efficiency to their amelioration of the soil conditions and, in particular, by inducing better root aeration. It was also shown that the best results to be expected from the manurial treatment of paddy will be obtained by using these indirect manures in conjunction with ammoniacal manures.

Incidentally, it was demonstrated that the roots of the crop cause the imprisonment of these gases in the soil, thereby conserving the marsh gas and making it available for root aeration during the later stages of growth. If this were not the case, much of the marsh gas would be oxidised during the early stages of growth, when the demand for root aeration is proportionately small. This fact, of the retention of the soil gases, also admits of a rational explanation being formulated regarding the change in composition of the soil gases under the action of the crop. (Memoirs of the Department of Agriculture in India Chemical Series, Volume III, No. 3)."

Field work in the Madras Presidency continues on the usual lines and steady progress is reported. Economical transplantation, decreased rate of seed in the nursery, sale of green manuring seed and also of selected paddy seeds are the chief directions of activity. Thomas reports that in the Southern Circle there is a fairly general diminution in seed rate to about one half of that formerly used, but it is not possible to give details of the exact area affected. Green manuring has been already referred to in this report. When

it is demonstrated to the ryots it is readily taken up. There was an increase in the sale of fish and phosphatic manures. In the Tanjore delta, 24,396 Madras measures of improved paddy seed were distributed. Hilson continues comparative tests of varieties at Samalkota in the Godaveri delta, and 20,000 lbs. of selected seed were disposed of. Work on paddy is now extending to the Malabar coast and the sale of selected seed has commenced there.

Graham reports from the Central Provinces that work on rice continues on the lines indicated in last year's report. The local varieties of the Central Provinces rices, which have been grown in pure cultures at Nagpur, are being tested on the Experimental farms. No. 12, a medium rice combining quality and yield, is becoming popular in the Northern Circle. No. 17, an early rice, is also being taken up in that tract and promises to displace the local early rice. The systematic study of wild rices in the Ceneral Provinces is being carried out. They appear to fall into three classes.

(1) *Tarra*, awnless or partially awned rices.

(2) *Karga*, erect, fully awned rices.

(3) *Pashar*, grass-like creeping rices.

The local vernacular names roughly correspond to these classes and have been used to distinguish them.

Evans, in the Northern Circle, working in collaboration with the Economic Botanist, tests the new varieties raised by him on a field scale, and several varieties are now grown to a considerable extent. Three hundred maunds of one variety alone (*Basmatia*) were sold during the year. The demand for seed is, however, far in excess of the supply, and seed farms are being opened as fast as possible to increase this. Generally speaking, early or early medium rices of good yielding capacity are required, but quality is also a consideration locally.

In the Southern Circle, Clouston reports that work on selection of paddies has continued at the Raipur Farm for the past twelve years. Of 100 varieties passed in review, some 19 are left, 5 early, 9 medium and 5 late. Of exotic varieties introduced only two have done well. In the early forms *Gurmatia* appears to be the best, a form which is said to have been introduced after the last famine. It is a heavy yielder, tillers extremely well, and has a low proportion of husk to grain. Among the early varieties *Bhata Gurmatia*, supplied for trial by the Economic Botanist, stands easily first. The *ropa* system (of transplanting paddy seedlings) is being steadily prosecuted and the average increased yield over the ordinary broadcasting has worked out at 400—500 lbs. per acre.

In Bengal, work is being pushed on with the paddies which Hector has isolated at Dacca, and local varieties are being compared with them on various district farms. McLean reports the following results of comparative tests undertaken in Mymensingh and Dacca districts on the ryots' fields. Dacca

No. 1 (Indursail) in 49 plots in Dacca district gave an average increased yield over that of the local kinds of 600 lbs., while the increase in 44 plots in Mymensingh was 330 lbs. As a result of these experiments, some 700 maunds of Dacca No. 1 were distributed, which should produce 50,000 maunds during the next year.

Less definite progress in paddy work is reported from other Provinces. Beale has published a note on the classification of paddies in Lower Burma. He discusses the schemes already propounded by Kikkawa and Graham and refers to the work of Hector, van der Stok and others. Meggitt reports that the pure line cultures started in Sylhet were irretrievably ruined by the floods of last autumn, both the plots and the seed stock being washed away. The work will have to be started altogether afresh. Burns, in Bombay, has made an exhaustive study of the third generation of a natural paddy cross, and 27 new artificial crosses have been made with the object of studying the behaviour of the characters in crossing, and to get material for breeding. A working classification of the rices has been prepared and will appear in the Annual report.

Wheat.—Some important work on wheat has been carried on during the year. The effect of green-manuring on this crop has been already referred to under that heading. The only purely scientific work is that of Howard and Howard on the inheritance of awning and felting of the grain, published in a Memoir of the Department of Agriculture in India, for a summary of which I am indebted to Parnell. "This study forms a continuation of the work published in an earlier paper (Memoir, Department of Agriculture in India, Botanical Series, Volume V, No. 1). The suggestion was there made that the fully bearded character of wheat was due to the simultaneous presence of two factors which, when present singly, gave rise to long tips and short tips respectively. This theory has now been confirmed by the results obtained in F. 3, which included progeny from each plant of F. 2 family. The ratio existing in F. 2 is thus shown to have been a 9 : 3 : 3 : 1, one which was complicated by further sub-division of the three major groups, owing to the fact that in the case of both factors the heterozygotes were of an intermediate character. Further proof was obtained by the production of fully bearded types in the F. 2 of crosses between certain strains showing long and short tips respectively. In the previous paper it was shown that complex felting involved two factors and that two types showed simple felting due to a simple factor. It has now been shown, by crosses between these two types, that the factor in both is identical. Both types were crossed with a type with complex felting and, in each case, the F. 2 showed that the simple felting factor was identical with one of the two factors producing complex felting."

The main work on wheats during the year in the United Provinces was the replacement of local varieties by Pusa 12 and Pusa 4, and a stage is being reached when it will be possible to see large areas of these varieties grown true to type. The year 1914-15 was, for the second time, a season characterized

by a shortage of moisture, and Pusa 12 once again behaved in a satisfactory manner. "If we take into consideration both quality and yield, the substitution of the country wheat by Pusa 12 would mean an immediate increase of Rs. 15 per annum, or £7,000,000 per annum for the whole of the United Provinces." These are large figures and some time must elapse before they can be realised, but "the seed already commands a premium of annas 4 per maund in the local bazaars." Such an increase will mean a surplus over local consumption which should enable India to take a considerably larger share in the production of wheat for the Empire at large. Pusa No. 4 has a more limited and specialized range. It has been found particularly useful in tracts like the Bundlekhand, some of the Central India States, the southern parts of the Bombay Presidency and parts of Bihar, where a strain is required which will ripen quickly, resist the early rusts and be contented with a short supply of moisture. Pusa 4 is giving good results under these conditions and is being rapidly taken up by cultivators. It has been introduced into New South Wales and is doing well there, a sample grown from seed supplied by Pusa having won the first prize at the Royal Agricultural Show at Sydney. The demand for seed is constantly increasing, and about 1,500 maunds were supplied to Burt for distribution in the Bundlekhand. In collaboration with Burt, 5,000 maunds of Pusa 12 and 4,000 of Pusa 4 were shipped to England at the request of the mills, but the report has not yet been received. Other wheat investigations are going on at Pusa and four series of exceedingly promising new crosses are being worked out in detail. Burt has contributed a note on an investigation as to the acceptance of Pusa 12 for local consumption, an important factor in the spread of this variety, and the results have been favourable.

A useful piece of work by Howard and Howard has been concluded on the saving of irrigation water for wheat in the Quetta valley. A constantly recurring fault in the irrigation of many crops in India is excessive watering, and, in spite of the limited quantity available in Quetta, they have demonstrated that a considerable saving may be effected there, thus rendering the water available for other plants, such as the much needed fodder crops. Experiments continued over three years show that a single irrigation, before sowing the wheat, gives a greater yield than the 5 or 6 usually given during the growth of the crop. The wheat, furthermore, ripens more quickly and thus escapes the drying winds which supervene at that time of year. A characteristic feature of the local wheats is that they do not ripen normally, but seem to be gradually dried up without the usual change in the colour of the chaff. By single watering this is changed and ripening takes place as elsewhere. The advantage obtained by growing a crop of *shaftal* before wheat is referred to under Green manuring. Attention is called to the cooling effect of the watering before sowing, and it is suggested that this innovation might be usefully introduced in other wheat growing tracts.

In the Punjab, a considerable portion of the time of the Economic Botanist is devoted to this crop. Milne reports that about 10 acres are under wheat

in the Botanical area at Lyallpur. The 25 originally classified types of indigenous wheats are being grown on in small plots, and 36 more have been added as the result of a survey. A number of the selected types have been handed over to the Agricultural section, and have been grown under field conditions with favourable results. Arrangements have been made to have millers' opinion on the new strains. Over 100 crosses are being grown, with No. IX at intervals for comparison. Of them, 72 have been selected for a further trial, and some appear to be very promising. Four types of Canadian wheat have been grown, but did not compare favourably with the local kinds. Incidentally, Milne has made a study of the number of whole grains of wheat capable of germinating which are passed by cattle fed on this grain. The number of such grains turns out to be extremely large (9-20·5 per cent. in the experiments), and he draws the attention of plant breeders to this fact, and points out the danger of introducing confusion in manuring pure line wheat plots. A large number of gram seeds were also passed intact but, in almost all of these, the germinating power had been destroyed while passing through the animal.

Evans reports the continuance of successful work on wheats in the Northern Circle of the Central Provinces. Locally selected varieties have, almost without exception, given much better results than introduced Pusa kinds. Some of the original selections are now grown over large areas in the localities for which they are best suited, and, on the average, they bring in an increased profit of Rs. 5 per acre. A conservative estimate gives the area at present under these new kinds as 100,000 to 125,000 acres. Better types are being continually produced, and attention is specially drawn to a particularly promising set of hybrids between a local selection and an Australian wheat (Warren). These are now being tested on a field scale. During the present year, the selection and hybridization work has been handed over to the Economic Botanist at Nagpur, while any new selections or crosses obtained by him will be tried on a field scale. Progress in this important work is thus rendered likely to be more rapid in the future, and Graham has started the selection and breeding work at Nagpur.

In the Southern Circle, the result of comparing local and introduced varieties of wheat during the past five years, coupled with selection, has shown that six varieties can be relied on as superior to the rest. Clouston states that Pusa 12 has, from the first, done well, and another variety promising to be useful is one received from Hoshangabad. As a result of irrigation experiments it has been demonstrated that, when the rainfall during the growth of the crop exceeds $1\frac{1}{2}''$, one irrigation is sufficient. Late wheats are unsuitable, in that they are dried up by the hot winds of March, and the two varieties mentioned above satisfy this condition.

Allan's work in connection with the effect of green-manuring before wheat has already been mentioned. A remarkably close correlation has been shown to exist in regions of poor rainfall between the amount of rain falling

between the inverting of the green manure and the sowing of the wheat, and the total yield of the latter in grain at harvest.

Owing to the dislocation of work in the office of the Economic Botanist at Cawnpore, Leake reports that the work on wheat has been confined to the multiplication of a promising selection, known as Cawnpore No. 13. The mass of detailed information collected on the indigenous wheats of the United Provinces remains uncollated, owing to the lack of opportunity for dealing with it.

Juar, Cholam (*Andropogon Sorghum*).—Graham has investigated certain of the unit characters of this plant and submitted his results in the form of a Memoir of the Department of Agriculture in India. The following are the chief conclusions :—" *Andropogon Sorghum, Brot.*, is protogynous. Normally the flowers are pollinated from the higher flowers of the same panicle. The flowers, although typically anemophillous, are regularly visited at certain seasons by insects, chiefly bees. This undoubtedly leads to natural cross-pollination, the liability to which depends on the structure of the panicle, being greater in laxer forms. Flowering takes place in fairly regular order. During the months over which the observations extended, the majority of the flowers opened between 2 and 4 A. M. Stray flowers may open before or after, this being favoured by atmospheric moisture. In the grain, the red colour and the yellow colour behave as simple allelomorphs, as also do the red colour and the white colour, red being in both cases dominant. Likewise, the yellow colour and the white colour may behave as simple allelomorphs, or the heterozygote may be red, behaving as a dihybrid with a 9 : 3 : 4 ratio for red, yellow and white respectively. The simplest explanation is that certain white grained plants are undeveloped reds, requiring the presence of yellow to cause the red colour to develop. In the glumes the long character and the short character behave as simple allelomorphs."

Hilson, in the Northern Circle of Madras, has made a collection from various parts of the Presidency for the purpose of providing a suitable fodder cholam for the Ceded districts, which should at the same time prove immune to short smut. He has paid some attention to a well-known correlation between the character of the midrib and the sweetness of the stalk. Plants with an opaque white midrib running through the whole leaf have pithy stalks insipid to the taste, while those with dull white generally interrupted midribs have sweetish stalks. Hilson has extended the observations of this correlation to various parts of the Presidency and substantiated it in different varieties. He has, further, studied the genetic composition of the plants with regard to this character and sums up his results as follows :—(1) The character of the green stem of *cholam*, *i.e.*, whether it is sweet or pithy, can be readily diagnosed from the appearance of the midrib of the leaf, when the plant is in short blade and for some time after, and (2) the pithy character behaves as a simple dominant to the sweet stalked character.

Little other work appears to have been done on this important crop. Burt reports that the testing of various types of *juar* isolated from the varieties

grown in Bundelkhand is being continued and that two of these have proved very much above the average and are being distributed on a large scale, and McKeral has collected the local forms growing in Burma and is making pure line cultures of these.

Sugarcane.—A good deal has been written lately on the subject of sugar and the sugarcane, attention being doubtless drawn to it by the prevailing high prices, owing to the increasing world's shortage in this commodity. Occasion was taken by Barber to discuss the question from the broader standpoint in a paper read before the Madras Science Congress, and printed in an abbreviated form in the Agricultural Journal of India. A comparison was there drawn between Indian conditions and those in the Tropics, especially Java from which the bulk of the Indian imports are obtained. A useful summary of progress up to date in India has been prepared by Sayer, also published in the Agricultural Journal of India, where branches of the industry are reviewed in turn. This is of great advantage to the general reader, who is thus enabled to obtain a comprehensive view of the situation and the possible lines of improvement, without having to go through the huge mass of literature which has accumulated. After a comparison between the average output in India and Java, sections are devoted to sugarcane cultivation in India and its improvement, extraction of the juice and its conversion into *gur*, the central factory system, and palm sugar. These two papers, published during the year, together with one by Clarke in 1913 on the World's Cane Sugar Industry, should be consulted by all who wish for a general exposition of the subject in popular language.

A Memoir of the Department of Agriculture in India (Botanical Series, Volume VIII, No. 3), now in the press, by Barber, contains an account of the work on the Cane-breeding Station at Coimbatore since its commencement three years ago, and the concluding summary may be consulted for more recent work in this part of the subject—that of improving the Indian sugarcane industry by the introduction of new varieties by raising seedling canes. Lists of seedlings obtained each year are given. The various difficulties in getting the land into order, in acclimatizing the introduced canes and in inducing them to flower so as to obtain the desired crosses, are detailed, together with the way in which these difficulties have been overcome. Special attention is given to the variations in morphological characters and the quantity of sucrose in the juice of seedlings of the same parentage, and attempts are made to correlate some of the former with the character of the juice, so as to be able early to make selections of seedlings of ultimate value. Thus, from an analysis of the length and width of the leaf and the leaf module (length divided by width) in batches of seedlings of the same parentage, a negative correlation has been demonstrated between length and width of leaf and the amount of sucrose in the juice, while the correlation between the leaf module and sucrose was positive. The thickness and length of the stem give less obvious results, but there is a general tendency for a negative correlation between thickness of cane and a positive between length of cane, and sucrose, whereas

the stem module (length divided by thickness) gives a very distinct positive correlation. There is, further, a positive correlation between width of leaf and thickness of cane, as well as total weight of seedling, whereas no correlation could be observed between width of leaf and tillering power. An interesting feature in these studies is that these correlations are only observable between seedlings of uncrossed parents, those which are known to be crosses behaving differently, the correlations being apparently disturbed by the respective characters of the parents.

The variations in morphological characters receiving special attention were vigour and size, general habit, erectness of young shoots, tillering, leaf tips, width of leaf, colour of leaves and colour and thickness of canes, and these are compared with the same characters in their parents. The striping of canes received some attention, and it is pointed out that the seedlings of striped canes are not striped, but split up into all shades of colour. In general, the seedlings, whether of striped or coloured parents, are half of them green and the rest coloured, the colour of the parent having only comparatively small influence.

Various methods are detailed by which it is hoped that the excessive labour of the chemical analysis of the juice of the 3,000—4,000 seedlings, grown each year to maturity, may be lessened. Analysis of the cane "up to dead leaf," *i.e.*, that part of the cane whose leaves have already died, appears to give a fair indication as to the ultimate sucrose content, and early Brix and sucrose determinations are used for the same purpose. It is impossible to analyse the whole 3,000—4,000 seedlings simultaneously and, of necessity, some will be under a disadvantage as to their state of ripeness, unless some such methods as these are introduced. The occurrence of two kinds of canes on the same stool, demonstrated in a former Memoir, has been worked out for a further number of varieties. The general conclusions hold, and it is shown that, while this character is present in certain classes of indigenous canes, it is absent in others. In the former, there are obviously two sets of canes in each clump, early and late, while in the latter no such differences exist, and all the canes appear to ripen simultaneously.

The Cane-breeding station has now been in existence for three years, and it is possible to form some idea as to the average length of time before a new seedling can, with any degree of safety, be introduced to the cultivators. Owing to the unfortunate fact that seedlings can only be obtained in October-December and that they take 18 months to mature, they are analysed in June-July, which is out of harmony with the local ripening season (February-March). A year is thus lost in bringing the seedlings into line with local conditions, and only two analyses can be made in the first three years. Two further years are considered necessary for determination of habit and vigour, and thus it is five years before a seedling can be sent out for testing in the locality for which it is supposed to be suitable. Giving a minimum of two years in the Provincial farm before it is possible to recommend the new cane to the cultivators, we see that seven years must elapse before any new introduction

can begin to have effect on the cultivators' fields. Some 100,000 seedlings have now been raised, and it is estimated that, of these, possibly a dozen new varieties may prove of ultimate value in the field. This works out at something like one in 10,000, a lower proportion than that assumed for Barbados, but considerably higher than the estimate in British Guiana, where only one out of every 26,000 is considered likely to be of use. Considering the special difficulties in the Indian conditions, this result is not regarded as unsatisfactory.

Further studies have been made into the relationship of Indian canes among themselves. Over 100 kinds have now been collected and acclimatised at the Coimbatore farm. These have been arranged in groups of obvious connection, but a large number have remained unclassified until this year, when the opportunity occurred for examining them more carefully. As the result of this examination, two new classes have been instituted, consisting of canes with no obvious resemblance but whose close relationship is shown by their agreeing in a large number of minute characters of less evident nature. These two classes have representatives in all parts of the country and examples have been collected from nearly every Province in India. A Memoir is in preparation, and it is hoped that, with the publication of this, some considerable progress will have been made in the classification of indigenous Indian canes.

Harrison has conducted some interesting experiments with refractometer determinations of cane juice. As a result of these he has shown (1) that in indigenous Indian canes the joints, for some distance beyond the highest dead leaf, contain juice of about the same index as the older ones, whereas in thicker tropical canes this is not the case but, after the dead leaf zone is passed, a rapid fall is met with. This seems to be a distinguishing mark between these two classes of canes. (2) It was shown that the refractive index of the juice in the lower joints of young canes was approximately the same as that in the same canes when mature. An attempt, however, to apply this to the selection of seedlings in the immature state failed.

Taylor, in Bihar, has continued his researches on the ripening of the different varieties of cane. In *Khari*, a typical early ripener, analyses were made from November to February, and the most profitable results were obtained by cutting from January to the middle of February. In this cane, and in *Shakarchynia*, good sweet juice was obtained as early as December. *Mungo*, *Rheora* and *Hemja*, on the other hand, are most profitably harvested in March. This difference in the ripening of canes of different classes is of obvious importance to the factories in the tract, as it shows a means whereby the milling season may be extended. Of various manures experimented with, Ammonium sulphate delayed ripening, but variations in the time of planting seemed to have little effect. A series of canes planted from November to March ripened practically at the same time.

In a paper, some of the results of which were referred to last year, McGlashin and Clouston deal exhaustively with the prospects of sugar making in the Central Provinces. The limiting factor appears to be the high price obtained

for *gur*, and they conclude that, under present conditions, the founding of a sugar factory in the Central Provinces is hopeless, whereas there is a bright prospect for smaller installations for preparing *gur* of a better class. It is considered that the area under sugarcane in the Province has now reached its minimum (a fall being recorded from 42,255 acres to 17,392 in the past thirty years) and that the area planted is likely to increase considerably in the near future, because of the opening up of large areas under new irrigation works.

In the light sandy soils in the Southern Circle of the Central Provinces, where canes are especially subject to red rot, the local cane grown is an inferior variety known as *Katai*. Clouston reports that this is being successfully replaced by *Sannabile* from Bombay and *Khari* from Bengal. J 247 has also succeeded, as it has proved to be less liable to this disease, and it is the chief variety grown on Mr. McGlashin's estate. Over eight lakhs of cuttings of these three varieties have been distributed during the year. As the result of experiments, it has been proved that enormous increases in the outturn can be obtained by (1) planting *Sannabile* and *Khari* in localities subject to the disease, (2) using top shoots for planting instead of whole canes, (3) planting from October 1 to the end of January instead of in February as is usually done, and (4) by heavy manuring. The application of superphosphate appears to be essential for obtaining the maximum effect of nitrogenous manures and green manuring. Shootborer may be got rid of by early planting.

Considerable activity is being displayed in the spread of new varieties in Malabar and South Canara, South Arcot, Partabgarh, Shahjehanpur, Bundelkhand and the Central Provinces, and important work is being carried on in Assam, Bombay and Burma, while the Bihar factories, taking advantage of the present high prices, are passing through a period of increased prosperity. In a paper in the press, Barber draws attention to the need of well-considered surveys of varieties of indigenous canes at present grown, such as that already made in the Punjab. Work in this direction is being actively carried on in Bombay, the Central Provinces and Bengal, and will materially assist the work of the Cane breeding Station.

Cotton.—In last year's report the early history of cotton improvement in Tinnevelly was discussed. A paper, read by Thomas before the Madras Agricultural Students Union in 1916, deals with later stages in this important work. To recapitulate, single plant selections are grown on small comparative plots and those not true to type are rejected. The plots are then increased in successive seasons to 5 cents and one acre and, if the results are satisfactory, they are grown in sufficient quantity to submit to spinners' tests. If these are favourable, then the type is grown on 400 acres under seed farm conditions, this bringing us down to the sixth year. The *kappas* is bought and ginned by the Department, and the seed is distributed to the ryots till grown on sufficient scale to be tested in bulk. In the eighth year the position is changed, and the cotton becomes a marketable commodity. During the current year Company No. 2 and Company No. 3 have thus been dealt with for the first time and a

critical stage has been reached in the history. Hitherto all the cotton has been sold to the local spinning mills at a nominal premium, steadily rising from Rs. 3 per candy of 500 lbs. in 1913 to Rs. 7 per candy in 1915. This year circulars were sent to exporting firms, promising 1,600 candies of No. 2 and 400 candies of No. 3. The Department offered to deliver the cotton pure to firms, and premiums were offered by the latter of from Rs. 4 to Rs. 10 per candy above the prevailing price. Only 120 candies being grown by the Department, a system of certificates was instituted, guaranteeing purity to the firm and the premium to the cultivators. The firms appeared anxious to obtain the cotton and a lively competition ensued, additional premia being offered perfectly spontaneously up to Rs. 16 per candy, a price higher than at present ruling for middle Americans. Samples sent to one firm in Liverpool were valued by the arbitrator at Rs. 197½ for No. 2 and Rs. 199 for No. 3, as against Rs. 189 for ordinary Tinnies. One sample of the latter fetched Rs. 197½, but on investigation it was found to be none other than No. 2 sold without premium. Altogether the new cotton works out at a profit of Rs. 12-14-0 to the cultivator per acre at present rates, this figure being reached by the addition of the premium, higher ginning outturn and sale of seed. The latter was in unprecedented demand and far beyond the Department's power to comply with. Thirty thousand acres are under Departmental control this year. It now becomes necessary for the Department to devise some system for pure delivery and a guard against adulteration. The best plan appears to be the elimination of the middleman and the removal of the source from which adulteration threatens. Certificates are now given to villages in place of individuals, and failure to comply with the conditions is punished by cancellation of the certificate and placing on the black-list for the ensuing season. It appears that a prolific cotton of poor quality known locally as "pulichi," has been introduced, and a regular campaign has been instituted with the aid of the buyers for its eradication. The efforts last year do not appear to have been entirely successful, but give a guarantee that the trade is in earnest, for all sales of cotton were made impossible for a fortnight, a lesson which is not likely to be forgotten, and the exporters are determined to continue the struggle.

In the Northern Circle of Madras, as a result of continuous selection work at Hagari and Nandyal, new strains have been evolved and seed distributed to the cultivators. During the current year 1915-16, 61,850 lbs. of Nandyal No. 2 and 26,773 lbs. of Hagari No. 1 have thus been sent out.

Some account was given last year of Clouston's cotton work in the Central Provinces. Selected lines of roseum cotton are maintained at Akola and Sindewahi for distribution to the seed farms. A cross between Deshi Lahore (*sanguineum*) and *Bani* (*indicum*) was made at Akola and has proved very successful at Sindewahi. The ginning percentage is 36 and the lint is worth 15 per cent more than that of *roseum*. Clouston reports that the irrigating of cotton grown on *wardi* soil has resulted in a great increase in the yield per acre. Two of the many thousand crosses tried have come out well, one between

bani and *roseum* and another between *bani* and *neglectum*. But as regards outturn *roseum* has proved the best and millions of pounds of seed are being distributed every year to the cultivators. The line of selection is to find out plants with large yield of *kappas* and high percentage of lint to seed. By continuous selection strains have been evolved which invariably give 40 per cent. or over of lint.

Evans writes from the Northern Circle—"In the Hoshangabad district *roseum* cotton is being grown on several thousands of acres. In the greater part of the North Central Provinces this cotton is too late, and early ripening varieties are required. A yellow flowered type named *Saugor Jari* has been produced on the farms and is now grown on large areas. Graham is also sending new types of early cottons for trial."

In the United Provinces, Leake reports that the second stage of the work in cotton has been reached. The types K 7 and K 22 have been widely distributed and the latter especially shows every prospect of proving a most valuable field crop. This latter form is considered the most valuable from a practical point of view, and about 100 maunds of seed have been distributed. The lint fetches about 20 per cent. more than ordinary *desi*. Burt continues to devote attention to the spread of American cotton and has isolated a number of forms in small plots. These are being tested for desirable characters and early flowering.

In an interesting paper in the Agricultural Journal of India, Volume X, Part IV, Roberts traces the history of American cotton in the Punjab. Twelve years ago there was practically no American cotton grown. In 1911, only 10,000 acres were reported, while last year there were 70,000 or more. The yield is better than the ordinary cotton and a premium of Rs. 1-8 can be obtained per maund. Taking the average outturn as 6 maunds per acre, this works out to Rs. 6,30,000 profit to the cultivators. The first attempt was made as long ago as 1884 when Upland Georgian seed was introduced. Mollison in 1902 experimented at Hissar with 27 new introductions and 5 acclimatised kinds. He found that the American plants grew strongly and developed as early as the first *desi*, and thus escaped the frost. In 1903 Lyallpur took up Cawnpore Acclimatised and Punjab Narma (the remnants of the 1884 introduction, of which a small sample was obtained with difficulty) and demonstrated that, for the new cotton to be successful, it had to be sown as early as possible. Systematic work was only possible, however, on the founding of the Agricultural Department in 1905. Sales were started which resulted in a uniform premium of Re. 1 per maund for Ammerican *kappas*. Dharwar American was found to produce an earlier cotton with better staple, but it was found to be very mixed and the smooth-leafed forms were much attacked by Jassids. Botanical work produced a large number of selections and crosses. In 1910, Nos. 3F and 4F were handed over for trial. Both proved to be big yielders but the former was smooth-leafed and therefore discarded. In 1914, there were 2,000 acres of 4F grown and, in 1915, 70,000 lbs. of seed were sold at Lyallpur at Rs. 3-12 per maund as against

Rs. 2-8 for the local seed, and many cultivators kept their own seed. Four sales of *kappas* obtained premia of Rs. 2 per maund and two at Lyallpur reached Rs. 2-13 and Rs. 2-9. The usual trouble has been experienced from the mixing of *desi* and short stapled Americans, but the critical period appears to have been passed and the American cotton to have obtained a firm hold. This has been largely brought about by a process of natural selection in which jassids and other diseases have had their share. Co-operation between the Agricultural Department, ginners and merchants has materially helped in the issuing of pure seed and obtaining satisfactory premia.

A considerable amount of work is being done by Milne in the Botanical area at Lyallpur, in the production of new strains of both American and *desi* cottons. There is, therefore, every prospect of progress being maintained, if not accelerated, in this crop. Milne considers that Americans should not be planted on very sandy soils, because, not only is the yield inferior, but there is marked inequality in the length and strength of the lint. The *desi* cottons, on the other hand, having shorter and rougher cotton are not affected nearly as much. A number of new strains have lately been handed over for testing, and some of these have been valued by Messrs. Tata and Sons, and compared with well known marks. The report indicates that the new varieties would sell for from 350 to Rs. 500 per candy of 784 lbs. as compared with Rs. 345 for Tinnies, Rs. 290 for Broach and Rs. 350 for Surat. In the near future some very interesting results are to be looked for from this work, but it is surmised that here, as elsewhere, progress will depend upon wholehearted co-operation between the Department and the buyers in maintaining pure marks. That this has not always been the case is evidenced by a fact stated by Roberts, that an exporting firm in Bombay actually *ordered* mixed American and *desi* cotton from its local buyer.

Oilseeds.—An important Memoir on this subject has been published by Howard, Howard and Abdur Rahman Khan, giving the results of several years of work on Mustard and Safflower. The two papers are short, but contain a mass of information on the crops, and may be considered as models of work in the study of Indian crops. Each is divided into four sections, introduction, biology of the flowers, form separation and description of types, and some economic aspects.

Safflower produces two different substances, a dye and an oil, and the uses of these are discussed. The former, on analysis, is seen to consist of of two colouring matters, one yellow and soluble in water and another, carthamin, insoluble in water but dissolving in alkali. *Kusam* oil is used as an adulterant for *ghi* and *til* oil. The details of flowering are carefully described, as well as the effect on pollination of enclosing the flowers in parchment bags and nets. The bad effect of the former is shown by experiments to be largerly due to the inhibiting influence of humidity and, probably, also to increase in temperature. The influence of the season is discussed, and it is shown that the setting of seed falls rapidly as it advances. Natural crossing in the field is discussed and the proportion of heterozygotes in different varie-

ties is estimated. It appears, from this analysis, that the forms grown in Bihar are very impure as compared with those of Bombay and while the forms collected from the United Provinces are very pure, those from Sind are very mixed. The classification of types is founded on general habit and the characters of the leaves, bracts and florets. A description of the types isolated is given as a basis for further classification of the agricultural varieties grown. As to the economic aspects of the crop, the colouring matter is found not to be antagonistic to the oil production, but the cropping value is shown to be dependent on other factors than the mere quantity of oil or colouring matter contained. Marsden, to whom samples of the dye were submitted, is quoted as maintaining the futility of carthamin competing with synthetic products. The chief value of the crop thus lies in the oil. For obtaining improved varieties form separation is the line clearly indicated. From the study of natural crossing in the field, it is concluded that, once an improved strain is obtained, it will be necessary to replace the whole of the local crop. The isolation of a better kind is thus only a step in the work and the rest is a matter of organization.

Mustard.—This crop is fairly extensively cultivated in the Gangetic plain, especially in Bihar and Bengal. Samples collected in 1909 from various parts of India proved nearly all to be mixtures of colza, mustard and rape. Type separation was confined to the mustard alone. Of 398 self-fertilized plants, only 102 bred true and these were used as the material for study. A summary is given of Prain's work on the classification of Brassica. As regards flowering, all late forms are stopped by the hot winds, whereas the early flowering forms set their seed before these commence. Pollination is described in detail. There are complicated arrangements for cross-fertilization by large bees, but seed sets easily under parchment covers and under nets. Some varieties show as much as 14 per cent. crossing in next to next rows. Thus, while self-fertilization is the rule, crossing may exist to a considerable extent in the fields. A description of the plant is given, adapted from Prain, and it is shown that classification is easy if morphological and agricultural characters are combined. The observation of mass habit is of special use in separating nearly allied kinds, but it has been found impossible to describe this in technical language. The chief characters found useful in form separation are the position of the pods, hairs on the leaves, mode of branching, height (correlated with time of flowering), growth period, etc. A description of varieties and summary classification are appended. The main line of improvement in the crop is considered to be increase in quantity, as nowhere does quality appear to be considered. There appears to be little field for hybridization work, and here also a botanical survey of existing forms, coupled with form separation, should precede it. A special difficulty in dealing with the crop is that the seeds have the power of resting for considerable periods. An example is given of seed continuing to germinate in certain plots for four years, and this must be guarded against in pure line cultures. For the intro-

duction of a pure strain into any tract, the whole local crop must be removed, a matter needing a considerable time and efficient control.

Sesamum.—Evans reports that a rabi variety of *til* with a dark brown seed is grown in the middle of the Nerbudda valley on about 80,000 acres. A new yellow-seeded form has been introduced during the past five years and is now grown in 35,000 acres, which, because of its increased yield and better quality, brings in Rs. 5 more per acre, and the market for this new kind is fairly well established. Single plant selections are carried out in the Powarkhera station, and the quality, which appears to be largely correlated with colour of seed, is improving year by year. Seed from pure lines obtained here are then tested on 13 other farms before being distributed to the cultivators. The improved varieties are termed *Purvi* or *Sirkari til*. In Burma McKerral has obtained 110 pure lines of local *til* strains. These are being tested for quality and yield, the oil being analysed by the Agricultural Chemist.

Gram and Tur.—A Memoir on Indian Grams (*Cicer arietinum*) has been published during the year by Howard, Howard and Abdur Rahman Khan. This was partially referred to last year and the following additional points appear to be of interest. The matter is presented in a form similar to that of Safflower and Mustard, already dealt with. The yield is shown to depend on several factors, including power to set seed, habit and branching, extent of root system and time of flowering. The value of the produce depends directly on the colour of the seed, the darker the colour the lower the price offered for it. The lines of form separation used are habit, size, colour and number of leaflets, colour of flowers and colour and size of seeds. The mode of fertilization is carefully described, especially with reference to the influence of moisture upon the opening of the flowers. The flowers are usually self-fertilized, but occasional crosses are observed, and the plants obtained from such crosses appear to split in the ordinary Mendelian ratios.

Sahasrabudhe, in Bombay, has made a careful study of the secretion of acid by this plant, first recorded by Hove in his " Tours " in Guzerat in 1787. He substantiates the work of earlier chemists in the presence of malic, oxalic and acetic acid in the secretion, and gives details of the quantities secreted in various stages of growth. There is a gradual increase up to the seed formation, including marked rises at flowering and pod formation, after which there is a rapid fall. It is a continuous flow and, if wiped off, will regain its former intensity in about six days. When washed off daily, the secretion is somewhat weakened but, in general, washing increases the total amount obtainable. He estimates that about 2,686 grams may be collected from an acre at a cost of Rs. 14.

Evans has succeeded in securing a good yielding early type of *Tur* (*Cajanus indicus*) which is now rapidly replacing the local late *deshi tur* in the Upper Nerbudda valley, which is annually injured by frost. The new form has a bushy, spreading habit, with white pods and seeds, and has been sown in 250 villages and is spreading as fast as seed is procurable.

Tobacco.—In Bengal, McLean reports that work is being continued on the Burirhat farm near Rangpur. Single plant selection is being carried on both with Sumatra tobacco to improve the leaf for cigar wrappers and with the local kinds to increase the yield and the number of spots on the leaf. The majority of the local Bengal tobaccos have been collected and studied as regards their botanical and agricultural characters.

Howard reports that there is a steadily growing demand for seed of Type 28 in Bihar and that it has been reported on favourably from Burma, the Central Provinces and Bundelkhand. At the same time, the cost of working the soil has been considerably reduced.

Indigo.—Parnell, in a Memoir of the Department of Agriculture in India, gives the results of experiments on the physiology of indigo-yielding glucosides.

" An indigo-yielding glucoside, commonly known to exist in the leaves of *Wrightia tinctoria*, was found also in the seeds and roots both of this species and of *W. tomentosa*, from the leaves of which it is absent.

The glucoside and its enzyme in *W. tinctoria* are distinct from those of *Indigofera arrecta* and *I. sumatrana* although *Wrightia* enzyme has some action on Indigofera glucoside and *vice versâ*.

Seeds of *W. tinctoria*, germinated and grown without nitrogen, show a steadily increasing glucoside content, whereas no increase occurs in the case of *W. tomentosa*. Such seedlings of *W. tinctoria* show a decrease in glucoside content when nitrogen starvation becomes apparent. A similar decrease is shown by cuttings of *Polygonum tinctorium* and *Strobilanthes flaccidifolius*.

This suggests that the glucoside may function as a nitrogenous reserve, but it would appear that this is not its normal function from the fact that in *W. tinctoria* and *I. arrecta* the falling leaf carries with it as much glucoside as it has contained at any period of its development.

Indican is produced in the dark by *I. arrecta*, and in both this species and *I. sumatrana* the alternation of day and night does not affect the indican content; moreover, in the latter species, no appreciable effect is produced by keeping plants in darkness for thirty six hours.

In the light of present knowledge no definite function can be assigned to indigo-yielding glucosides in general or to the glucoside of any special species."

Owing to the shortage caused by the war there is considerable activity in indigo growing in India. In Madras the demand for seed was so great that the Agricultural Department had great difficulty in procuring it for the cultivators. Trial crops did remarkably well on the Palur farm (originally founded partly for the study of this crop) and the cultivation of indigo interfered in places with the campaign of green manuring with *kolinji* (*Tephrosia tinctoria*). This reversion to the practice of long ago cannot, however, be looked on as other than a gain, because of the well known ameliorating effect of indigo on the soil.

Medicinal Plants.—Leake has continued to devote attention to OPIUM (*Papaver somniferum*). As indicated in last year's report, the scope of this investigation has been largely extended. A detailed account of the year's work forms the subject of a report to the Government of India and a brief reference here is alone, therefore, necessary.

"The preliminary object with which the experiments were undertaken was a study of the diseases of the poppy plant. These have been studied in collaboration with the mycological section of the Pusa Institute and point to the following conclusions. The wilt of the poppy is mainly a question of cultural conditions and, where these are satisfactory, little loss will arise from this cause. The disease caused by blight (Peronospora) falls into a different category. This disease is universal and largely dependent on the climatic conditions. Different races, however, show marked divergence in their capacity for resisting the disease and the best method for approaching the problem appears to be the selection of such resistant races—a work which is now in progress.

The question of morphine content is much more complex and work in this direction can only be said to have entered the preliminary stages. It forms the subject of a separate detailed report to Government."

There appears to have been considerable activity in the investigation of other medicinal plants because of shortage due to the war. Thus, HENBANE (*Hyoscyamus*) has been studied in no less than three places. Thomas conducted experiments with it in Koilpatti in the Tinnevelly district, with seeds obtained from a merchant in Tuticorin. The following practice, as a result of experiments, was considered the best. Sow early in November and transplant a month after to a foot apart. In March flowering takes place and a few fruits are formed. The crop is cut at the end of the month. The samples were sent to the Medical Stores Department and it transpires that the preparation from the leaves alone gave a better outturn than that obtained from the leaves and flowers, in which form it is usually imported. Gage reports that several plots of Henbane were laid down in the Royal Botanical Gardens at Sibpur and that the analysis of the dried leaves showed the normal alkaloid content. Barnes, devoting his attention to the indigenous Hyoscyamus of the Punjab, points out that this occurs in large quantities in various places. An analysis showed that it had far more hyoscamine than the European species and that this occurred in a purer form, as much as ten times the usual amount of the alkaloid being obtained from his specimens.

Thomas draws attention to the great increase in SENNA growing in the Tinnevelly district, long renowned for the production of this substance. There is the usual complaint however of adulteration, this being apparently largely by leaves of *Cassia auriculata*. The interesting *Carum copticum* is commonly grown on the black soils of the tract and in it too there is considerable increase. This plant is the source of the *omum water* so commonly drunk in India and contains as much as 50 per cent. of thymol in its oil.

IPECACUANHA cultivation has considerably extended in the Cinchona plantations at Mungpoo, as many as 30,000 plants being added to the stock. A considerable quantity of DIGITALIS was cultivated and seeds of *Gynocardia odorata*, *Hydnocarpus Wightianus* and *Taraktogenos Kurzii* were supplied to various places in connection with the treatment of leprosy, as well as material for the investigation of the poisonous properties of *Lathyrus sativus* seeds. Investigations are further being carried on into the resources of the various kinds of ASSAFŒTIDA.

Cinchona.—Last year the annual report of the Government plantations in Bengal was reviewed. In the present annual report, the financial position is fully stated from March 1900 to March 1916. It is shown that the surplus at the end of the period is "equal to a return of 3 per cent. per annum on the sum invested each year from the year of its investment to the end of the period." The report goes on "it is hoped that this exposition will make clear that, under conditions of presentment as stringent as few commercial companies would choose to adopt, the financial side of the Department's work is as satisfactory as the scientific." Considerable quantities of the best seed and full information regarding cultivation were supplied to the Forest Department of British East Africa and the Medicinal Plants Board of Victoria to aid in establishing plantations. "This is significant in view of the fact that so small a proportion of the world's supply of bark is grown within the Empire." The Madras plantations appear to have passed through a period of neglect, but the appointment of an Economic Botanist is a first step towards improvement. It is hoped that the staff will be further strengthened in the near future.

Fruit.—A considerable amount of work has been done during the year in the study of fruit trees and plantations. This is mostly of a desultory nature, but the results are in some cases of so promising a nature that the question arises whether the time is not rapidly approaching when a Pomologist may not with advantage be added to the Imperial Staff, whose duty would be to co-ordinate the scattered work that is being done.

Burns has continued his studies of the Mango plant. Some of his results may be summarised as follows. "The flowering of mango grafts may take place at any time after the operation but the setting of fruits takes place only after a certain number of years. This is not due to defective pollination. It appears to be connected with the gradual perfection of the union of the stock and the scion. Mangoes cannot be forced to flower by the methods used for the orange and similar trees. It appears that the flowering of the mango is a matter of internal rhythm and is largely independent of external circumstances. Canning of the mango fruit and juice has been successfully carried out, but with a large percentage of failures due to defective cans. It appears that for each variety the pressure and temperature must be gauged accurately in order to obtain a satisfactory product. Four hybrid mango plants produced last year are growing vigorously." A paper has been written by Burns and Prayag on the classification of mangoes. After reviewing previous attempts

in this direction a scheme is laid down which depends mainly on the shape and character of the fruit, and a diagram is produced showing how the measurements should be taken. Other work on fruit trees by Burns may be summarised as follows :—" Experiments show that Orange gardens can be greatly improved by green manuring *plus* bone meal, and farmyard manure, combined with correct pruning. The pruning of the Guava has also been taken in hand. Pruned plants produce from four to eight times the yield of non-pruned plants. An attempt is being made to train the guava on wires like a vine and to develop fruiting spurs. Guavas not so trained are being given an open urn shape and headed low. Red guavas grafted on white do not change their colour. An attempt is being made to breed a race of Papaya with a large number of bearing plants, and the means adopted is to cross the ordinary pure female type with the type which bears perfect and also male flowers on the same tree. The first generation cross is now coming into bearing. In the case of Figs, a mulch in November has proved positively injurious, inducing a cold damp soil, and causing yellowing of fruits. Digging and aeration at once remedied these symptoms. An attempt was made to get two bearing seasons into the dry weather instead of only one as now taken. This was partially successful. One important thing seems to be the removal at an early date of the unprofitable rains fruits, and the saving of the strength of the tree for the dry weather flowering. The pruning of the fig is being attended to, since with this operation is connected the awaking of the plant into growth at the proper time. In the case of Custard apple it has been found possible to gradually shift the flowering and fruiting seasons so as to get fruit in the hot weather. The only difficulty is the scarcity of irrigation water at this time. In Bananas an exhaustive study of the structure of the inflorescence and flower has been made and this will be the subject of a separate paper later on. Plants of yellow variety have been crossed with a red variety but as yet no trace of red appears in the crossed fruits although mixed bunches occasionally occur in nature."

Howard continues his work at Quetta and material has rapidly accumulated, but the details are deferred until next year's report. For the rest, the work in the Central Provinces appears to be the most important, although isolated experiments are reported from all over India.

Evans, in the Northern Circle, has devoted attention chiefly to Plantains and Oranges, and plantations have been laid down in various places. A paper has been published on Orange Plantations at Nagpur by Graham and the Superintendent of the Government Gardens in which the local practices are criticised and many improvements in irrigation, manuring and general treatment are suggested.

Milne, in the Punjab, reports continued progress in the importation of Arabian Date trees to replace the local ones. " The fruits from the imported Arabian trees are annually of better quality than those from the best local trees and these in turn are of far better quality than the average local fruits. Arabian fruits were sold last year at Rs. 0-6-0 per lb., done up in card-board

boxes, and the demand for these could not be supplied. The average value of the fruits from local date trees is about Rs. 2-8-0 per maund and the whole crop of dates in the province is worth 17½ lakhs rupees approximately. If only Rs. 0-1-0 per lb. (Rs. 5 per maund) were got for fruits from the Arabian trees and the local date trees were replaced by imported trees and hand pollination were resorted to, the value of the crop would be raised to about Rs. 70,00,000 per annum approximately ; also very large areas of land, more or less waste at present on the western side of the province, could be turned into most profitable lands by planting them with dates. A publication on the subject in English is in the press and one in Urdu will follow soon."

Tea and Coffee.—It has been found impossible to summarise the work being done on these two important crops, and attention is merely drawn to a few papers copies of which have been received. Anstead, before the Coffee Planters Conference, drew attention to the necessity of breeding work, in that, with trees of the same strain grown continuously for 20 to 40 years, it was obvious that deterioration had set in. More useful work was likely to accrue from selection among existing trees than the continued importation of seed from other countries. After drawing attention to the successful results obtained some years ago in the Dutch East Indies, he referred to the remarkable series of hybrids obtained by Jackson in Coorg and continuously selected for the past eight years. The seventh generation of some 700 trees were, with four or five exceptions, true to type, growing freely on a piece of very poor land and promising to yield a bumper crop. The average number of berries was 1,800 per tree, which works out at 15 cwt. per acre. The plants were healthy and free from disease and had a large proportion of pea berry. The value was slightly below that of good arabica, but this was more than counterbalanced by the great yield. In considering the necessity of improving the local strain, it must be remembered that one is sowing seed which is to give yield and profit for from 20 to 40 years.

Fletcher has published an important bulletin on the Fertilization of coffee. He determined that insects are not particularly necessary for pollination but that, since cross-pollination is more effective, bees are to be considered as useful agents. Self-fertilization is kept as a reserve in case crossing is not possible.

TEA has been referred to under the heading Green manuring. Before studying its diseases, Tunstall, the Mycologist to the Indian Tea Association, made a study of the root system. He compares the root systems of tea plants grown in sandy soil, clay, *bheel*, water-logged and hard pan soils. This has led him to the conception of an ideal root system for the tea plant, which he describes. It should be so developed as to be least affected by minor climatic changes and by the operations necessary to keep the soil in condition.

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Part II.—Forest Botany.

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Oecology of Sal (*Shorea robusta*).—Work was continued with the object of identifying the factor detrimental to root-growth which has hitherto been roughly defined by the expression *bad soil-æration.* This work has shown that whereas 92 per cent. of *sal* seedlings remained healthy in water-cultures for 78 days, 93 per cent. of the plants cultivated at the same time in badly ærated soil died during a period of 67 days. This clearly indicated that water alone could not be the injurious factor. The experiments further showed that water when held for some time in contact with the local *sal* forest loam, becomes heavily charged with carbon dioxide and impoverished as regards its supply of oxygen. Both in the Dehra Dun garden and in the local *sal* forests, also, the experiments have shown that liming the soil immediately before sowing has a decidedly detrimental effect on the germination and development of *sal* seedlings. It seems possible that this is due to accelerated bacterial activity resulting in an increased production of carbon dioxide and

in a diminution of the oxygen supply. Further experiments are, therefore, now being undertaken to test the effect of these 2 gases in varying quantities on the roots of *sal* seedlings. The Botanist read a paper on soil-æration at the Science Congress held in Lucknow in January and another paper on the factors influencing the growth of *sal* seedlings at the Board of Forestry in Dehra Dun in March. He also toured in the Kheri Division of the United Provinces in March for the purpose of giving advice regarding the management of the local *sal* forests.

Remedies for Bad Sal Reproduction.—Experiments carried out in the local *sal* forests during the year provided additional evidence regarding the advantages of the method of regenerating on cleared strips and patches which was advocated in last year's report. The year was a particularly trying one for *sal* seedlings owing to the heavy rainfall in August and September and the unusually dry hot season which followed. Sowings in the open, without side-shade, resulted in only 2 per cent. of healthy plants at the close of the year, sowings in the shady forest resulted in 6 per cent. of healthy plants, while sowings on cleared lines and patches, 60—100 ft. in width, resulted in 36—42 per cent. of healthy plants at the close of the year. A square of 180 ft. side gave only 26 per cent. of healthy plants which indicates that in the particular forests under reference an opening wider than 100 ft. in diameter is not advisable.

Sal Root-disease (*Polyporus Shoreæ*).—From November to January the Botanist toured in the *sal* forests of the Jalpaiguri and Buxa Divisions of Bengal and studied the local conditions in those forests where the disease was especially prevalent. The inquiry indicated that a condition of bad soil-æration caused either by excessive shade and undergrowth or by the compacting of the soil by grazing apparently favoured the disease. Experiments have, therefore, been initiated in the local forests with the object of testing the effect on the disease of clearing the undergrowth, burning and working the soil. In co-operation with the Imperial Mycologist, also, arrangements have been made at Dehra Dun to test the effect of inoculating with the disease the roots of *sal* plants growing under varying conditions of soil-æration. The disease is undoubtedly very widespread and has been reported already from Assam, Bengal, Bihar and Orissa, United Provinces and the Central Provinces.

Oecology of Teak.—The experiments carried out showed that complete removal of the overhead cover stimulated germination of the seed and the vigorous growth of the seedling. Under shade, teak seed tends to lie dormant for several years and if the seed does germinate the seedling growth is poor. This appears to indicate the advisability of more or less extensive clear-fellings for the purpose of obtaining teak reproduction.

Trametes Pini.—Local officers in the Punjab have accepted the conclusion quoted in last year's report that this disease of *Pinus excelsa* is chiefly caused by lopping and during the year all lopping of the pine in the demarcated forests of the Kulu Division was prohibited.

Local forest floras.—The two descriptive lists for the Central Provinces are in the Press, while Mr. Parker's forest flora of the Punjab and Mr. Parkinson's list for the Andamans will be shortly sent to the Press. Rai Bahadur Upendranath Kanjilal published a preliminary list for Upper Assam during the year.

List of Publications.

ANONYMOUS . . Sandalwood. (*Ind. For., xlii, p. 33.*)

HAINES, H. . . Key to Forest Flora of the Southern Circle, Central Provinces. (*Ind. For., xli, pp. 259, 408, xlii, p. 129.*)

HOLE, R. S. . . Natural Reproduction of Sal. (*Ind. For., xli, 351.*)

" . . Teak Reproduction. (*Ind. For., xlii, 51.*)

KANJILAL, U. . . Preliminary list of plants of Upper Assam.

LUSHINGTON, P. M. . Spike Disease in Sandal. (*Ind. For., xlii, 61.*)

NAYADU, S. . . Habits of Pterocarpus Marsupium. (*Ind. For., xlii, 287.*)

QADIR, A. . . . Pterocarpus santalinus seedlings. (*Ind. For., xlii, 27.*)

RUSHTON, W. . . Identification of wood of Indian Junipers. (*Ind. For., xlii, 211.*)

TROUP, R. S. . . Cultivation of Podophyllum Emodi. (*Ind. For., xli, 361.*)

" . . Natural Reproduction of Sal. (*Ind. For., xlii, 57.*)

WHITEHEAD, T. A. . A possible cause of " spike " in Sandal. (*Ind. For., xlii, 243.*)

WILSON, C. C. . . Sandalwood. (*Ind. For., xli, 247.*)

BOTANY.

PART III.—MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

PLANT PATHOLOGY.

Agricultural Research Institute, Pusa.—The following is an account of the chief investigations at Pusa during the year.

Rice.—The most important disease at present under investigation is that known locally as "ufra," which continues to extend and is causing widespread alarm in Eastern Bengal. Practically the whole of the districts of Noakhali, Tippera and Dacca is now infected and extension is going on into Mymensingh and probably Sylhet. The loss caused in those areas—and they are many—where the main crop is deep-water paddy and little else will grow, is very great. Estimates are difficult to obtain, but it has been calculated that in a small portion of the Bhowal Pargana of Dacca District over $2\frac{1}{4}$ lakhs of rupees, worth of paddy is annually destroyed, and there have been many reports of the misery to which the people of some of the villages have been reduced. Conclusive evidence has been obtained that the cause of the disease is the microscopic eelworm *Tylenchus angustus* Butl., described in 1913. The parasite hibernates in the dried stubble which covers the fields after the harvest of the main crop in November-December, and renews activity with the coming of the floods and high humidity of the rains. It is a semi-aquatic species, surviving for some weeks in water but unable to grow or moult under such conditions. It is actively motile in water and can travel both with and against the stream to reach its host plant. On a dry surface it is unable to move, unless the humidity of the surrounding air is high, but tends to coil up and pass into a dormant condition. Hence extension is limited to the period of high humidity and flooding, and the first patches of disease are not usually seen before July. On reaching the host plant, the worm ascends, if the humidity be sufficient to permit movement, moving in a minute drop of condensed moisture around the body. It makes its way as rapidly as possible to such parts of the plant as have unthickened epidermal walls, penetrating especially into the folded leaf-bud to reach the youngest leaves in the centre of the shoot, but liking also the flexible stem region just above the upper nodes, and the young ear and florets. Feeding and consequent injury

to the plant is limited to these regions, as the feeding apparatus is unable to penetrate the more solid parts. At no period is the worm found actually to enter the tissues; it lies on the surface and sucks out the juices through perforations made by a fine spine. Artificial inoculations on small seedlings may give visible results in a week, while on full-grown plants the first symptoms may take a month to appear. If the number of worms is large, death may occur within a couple of months, but in very many cases the plant is only weakened, not killed. Complete or partial sterility, failure of the ear to emerge from the sheath and failure of the grains to mature, are common consequences of the attack. It was found possible this year to carry the worm in an actively parasitic condition through its normal period of dormancy (say from December to April) by supplying it with continually renewed young paddy seedlings, kept surrounded by moist air. In dry air, however, the inoculations failed. So far the experiments at Pusa indicate that if the above-ground parts of the plant are dry, extension does not occur, and this explains the comparative immunity of the early ("aus") crop, and of the main ("aman") crop in its earlier stages. It is probable also that the spring ("boro") crop is not liable to injury, but this point has not yet been settled and the crop is, in any case, of relatively minor importance.

Experiments show that a diseased plot will inevitable give a diseased crop the following season if the stubble is allowed to rot on the ground as is the usual practice in the infected area, but if all the stubble is destroyed a healthy crop can be grown. Several experiments have been carried out to test the ability of the worm to remain alive in the soil, but it does not seem able to survive in this way between successive crops. Hence the treatment resolves itself into dealing with the stubble, and work is in progress in collaboration with the Bengal Department of Agriculture to test the best way of removing or destroying this. Thorough burning has been proved to be effective on small plots; ploughing in the debris of the crop as soon as possible after harvest may prove equally satisfactory; or a combination of the two may be found most convenient. The transplanted " aman " fields are rarely damaged, owing probably to the practice of harvesting this crop with most of the straw, but there is scarcely any other part of India where the stubble is left to rot in such quantity as on the lower class of land in the eastern districts of Bengal. The Bengal Department is carrying out extensive experiments and has commenced demonstrations in destroying stubble; early ripening varieties, which suffer less than the later kinds, are being tested; and an detailed survey of the infected tracts is also in hand.

Orobanche on tobacco and mustard.—The work of the past two seasons has established that the parasitic species of *Orobanche* in Bihar are *O. indica* Ham. and *O. cernua* Lœfll. The species *O. cernua* is the common parasite of solanaceous crops in Bihar, but does not appear to attack *Cruciferæ* save in very exceptional circumstances. In a crop of mustard, grown in a field known to be badly infected with both species of *Orobanche*, only four cases of *O. cernua* were found among many thousands of *O. indica*. The parasitism of

O. cernua therefore is more restricted than is that of *Oi ndica* which, while being a serious parasite of *Cruciferæ*, does occur to a not inconsiderable extent on *Solanaceæ*. The life histories of the two species seem to be identical, the "tokras" appearing a few weeks after the host crop is well established and rising to flower and fruit along with it. Both species rely on the production of countless millions of minute seeds for their dissemination and perennation. These seeds are present all over the cultivated lands of Bihar, their number and minute size being extremely favourable to their dispersal in the strong winds of February and March when the fruits of *Orobanche* are ripe.

Experiments were carried out during the year with a view to discovering whether the addition of quantities of sodium nitrate to crops of mustard and tobacco had any influence on the number of tokras which occurred in the crops. Plots of equal size were selected in land which was known to be infected with both species of *Orobanche*, and the numbers of tokras occurring in plots to which sodium nitrate had been added were compared with the numbers of tokras in plots which had not received any nitrate. A difficulty which renders the results of the first season's work on these lines somewhat inconclusive is that the number of tokras appearing in a plot will depend, apart from any influence of artificial manures, on the amount of tokra seed which the plot contained. This factor appeared in many cases to mask any effect which might have been due to the addition of sodium nitrate. The work will be continued for another year in order to eliminate this source of error but the results obtained to date do not lend any support to the view that sodium nitrate will be found a specific remedy for tokras.

Black thread of rubber.—Work on the "black thread" disease of *Hevea* in Burma was continued. A popular account was published as a bulletin of the Burma Department of Agriculture and a more technical memoir is in the press. The disease first breaks out soon after the rains begin and completely disappears after the close of the monsoon. It is not fatal to the tree but does much damage by attacking the tapped area of the bark. Infected areas do not yield latex and severely diseased trees have to be excluded from the tapping round. In 1914 the loss of rubber on one estate was 2-3,000 lbs and in 1915, 8-9,000lbs., there being 12,000 trees affected in 1914 and 42,000 in 1915, out of 77,000 in tapping. The cut surface of the tapped bark becomes marked by vertical cracks, from which latex occasionally exudes ; sometimes a thick cushion of coagulated latex forms below the renewing bark, causing the latter to bulge out and ultimately fall off, so as to leave an open wound. The renewal of the bark is irregular, masses of callus appear on the cut surface and further tapping is hindered.

The cause of this damage is a species of *Phytophthora*, differing from the well-known canker fungus, *Phytophthora Faberi*, to which it had been attributed in the Dutch Indies. It seems to occur in Ceylon also but has been there supposed to result from climatic conditions. In South India the same fungus is believed to be responsible for considerable damage and is at present under study by the Madras Department.

The fungus is found both in the diseased bark and also on the fruits. It has been grown in pure culture and an extensive series of inoculations carried out both on rubber and on numerous other plants known to be attacked by species of *Phytophthora*. On rubber it is a wound parasite, being unable to infect the undamaged bark ; through wounds it infects readily and produces the characteristic symptoms of the disease. Of the other plants tried, the ordinary hosts of *Phytophthora infestans*, *Ph. parasitica* and *Ph. Colocasiæ*, the three species most commonly found in Northern India, are immune, as also is cacao, one of the chief hosts of *Ph. Faberi*, and many other plants known to be liable to *Phytophthora* attack. Only on seedlings of the garden plants, *Gilia* and *Salpiglossus*, were successful infections secured.

The disease is favoured by excessive humidity and shade and is, therefore, worst in thickly planted rubber estates. The free admission of sunlight and air checks its progress, and good results may be obtained from judicious prunning and thinning. The chief source of infection seems to be the fruits, and as these have practically no value and develop in the rains a copious growth of the parasite, from which spores are shed on the bark, it is recommended that all fruits be carefully picked and destroyed before the monsoon breaks, in infected plantations.

In continuation of the studies on allied species of this genus which have been carried on at Pusa in recent years, an account of a form of *Phytophthora parasitica* found on *Vinca rosea* has been recently submitted for publication. Germination of the durable type of spore (the oospore) has been obtained and was found to correspond in essentials with that described for *Ph. erythroseptica* in Ireland.

Opium poppy blight.—The investigation of this disease has led to the conclusion that while *Peronospora arborescens* is a normal parasite present in almost every poppy field and probably, like most of its tribe, only epidemic under favourable climatic conditions for its spread, *Rhizoctonia* develops chiefly in fields in which the drainage is defective. The Economic Botanist, United Provinces, has discovered certain varieties which appear to be almost immune to *Peronospora* and in the growth of these and improved cultivation and drainage lies the best hope of preventing loss of the crop.

Rhizoctonia.—A joint paper on this genus was published by Mr. Shaw, Officiating Imperial Mycologist, and Mr. Ajrekar, Assistant Professor of Mycology, Agricultural College, Poona. The species dealt with are *R. Napi* West, an omnivorous parasite first observed in India in 1914, and *R. destruens* Tassi, which attacks potato, betle vine, lucerne, groundnut and suran (*Amorphophallus*). Evidence was obtained that the genus as at present defined is an artificial one, including representatives of at least two distinct classes of fungi ; occurring as they do usually in the vegetative condition only, identification is difficult, and the difficulty is increased by their omnivorous tendencies, groundnut, for instance, being liable to attack by at least three species. The

biology of the forms, especially *R. destruens*, was studied and suggestions for treatment are given.

Samples of jute seed from Dacca were found to contain the sclerotia of *Rhizoctonia Solani* Kühn adhering to the seed. The parasitism of this fungus upon jute has been the subject of a previous publication, but up to the present *R. Solani* has been a source of damage in the region of the " collar " and has not been known to infect seed. It is not clear how this comes about and the matter will receive further investigation.

Specimens of sugarcane received from the Central Provinces were found to be infected with a sclerotial fungus. The fungus was obtained in pure culture and strongly resembled *Rhizoctonia destruens* Tassi. ; moreover inoculations upon *Delphinium* (the original host of *R. destruens*) and upon betle vine were successful. Further infections upon sugarcane resulted in the death of the outer leaves and of the young shoots at the base of the plant ; the infections are still progressing at the moment of writing. In the field the fungus causes a bright red spot on the leaf sheath and this is the first noticeable result in artificial infections. In badly diseased specimens the leaf bases are a dark red and have a fibrous appearance as if the parenchyma had been rotted away leaving the vascular bundles. On stripping the leaf bases the stem has a pale pink colour under the epidermis, and in section the interior shows a generally diffused salmon pink colour, partly obscured by a thick white felt of hyphæ. The mycelium shows a tendency to form strands of hyphæ in a manner suggestive of *R. destruens*. Further research is in progress.

Anthracnose of peppers.—The disease of betle pepper referred to in previous reports as being probably due to an anthracnose fungus, has proved more difficult to elucidate than was anticipated. All attempts to produce it artificially by inoculating with cultures of the suspected fungi have failed. In the absence of definite knowledge of the cause no useful recommendations for treatment can be offered.

The chilli anthracnose (due to *Colletotrichum nigrum*) is a serious disease of this crop in several parts of India. It was prevalent in Bihar last year and some spraying experiments were tried. Later on it appeared that a more hopeful line of treatment lay in the use of disease-free seed and investigations are in progress to test this method. It has been found that, as in the allied bean anthracnose, the parasite penetrates the pod and reaches the seed. If such seed be sown the following season a certain number germinate and give seedlings on which the fungus may be found. Such seedlings must serve as a source of infection to their neighbours and it seems probable that this is one of the main ways by which the disease is perpetuated. If seed only from healthy pods be used this source of infection can be eliminated and further experiments are in progress to test the effect of this on the subsequent crop.

Plaintain diseases.—An account of a plantain disease prevalent at Pusa was published early in the year. It is a wilt, caused by a species of *Fusarium* allied to, but distinct from, that which causes the dreaded " Panama " disease

of the New World. The parasite was grown in pure culture and successful inoculations with it secured. In mild attacks the growth of the plant is not checked but in more severe cases the rot reaches the stem and may kill the whole crown. Much loss is also caused when the stalk of the fruit bunch becomes attacked as this may lead to total destruction of the bunch. No method of treatment has been found.

A second plantain disease, familiar in India, is the fruit rot caused by *Gloeosporium musarum*. Attempts to check this by spraying have been in progress for a considerable time. It has been found that early spraying with Burgundy mixture, beginning in June and repeated every fortnight until the fruit is nearly ripe, when ammoniacal copper carbonate should be used, is successful in preserving the fruit from the disease. An account of the method has been published.

Sal tree disease.—The disease of sal trees, mentioned for the first time in the last annual report has appeared again this year in the forest of Buxa Duars and is also reported in the Gorakhpur division. The symptoms of the disease and the fungus which occurs on diseased trees are exactly the same as in the previous description. Specimens of the fungus sent to Kew have been identified as *Polyporus Shoreæ* Wakefield —a species new to science— and the description published in the Kew Bulletin. The fungus is said to be readily distinguished from other species by the hard but brittle texture of the pileus, especially of the pores when dry, and the wrinkled deeply cracked dark crust. In living specimens the soft swollen whitish margin of the pileus is a distinctive feature. The basidia are normal and each bears fine hyaline spores from 2·5 to 3·5 μ in diameter.

In culture the fungus grows well on a variety of media. On glucose agar the mycelium is largely submerged and produces a dense brown pigment; the hyphæ very often segment into spores. On sterile corn meal the fungus nearly always produces structures which suggest fructifications; so far however they have not produced any basidia or spores. The excretion of a yellowish liquid is a feature common to these structures in culture and to the pileus in the field.

Inoculations were carried out in the jungle at Rajabhatkhawa in September of last year but defects in the method of this preliminary experiment, combined with the lateness of the season at the time of making the infection, proved unfavourable and no conclusive results have so far been obtained. The inoculations were repeated this June with modifications suggested by the previous experiment and a further series of infections is about to be carried out at Dehra Dun in co-operation with the Forest Botanist; it is hoped that these will yield decisive results.

Wilt diseases.—Wilts of cotton, til, gram, chillies and other crops have continued to engage attention. Nothing has been found to support the suggestion made by other investigators that this class of disease is due to defective physical conditions in the soil, especially to interference with the

supply of air to the roots. On the contrary our experience is in harmony with that in other countries such as Germany and the United States, that the principal factor involved is the presence of the parasite (*Fusarium*). As stated by Orton in the United States, " the plants are attacked when otherwise healthy and growing in soil, which, previous to its infection by this fungus, was ideal for their best development. The disease occurs in fields that are neither too dry nor too wet." " If anything, wilt is worse on highly cultivated and well fertilized fields." " Wilt occurs principally in sand, sandy loam, and light alluvial soils."

Miscellaneous.—The question of legislation for the prevention of the spread of plant diseases is one that is attracting much attention at the present time, and in 1914 a draft International Convention for the purpose secured wide support, being signed by the delegates of some 30 States. The writer has carried out a detailed examination of the facts on which international legislation of the kind should be based and especially of the means of dissemination of parasitic fungi, and has recently submitted some papers on the subject for publication.

OTHER SCIENTIFIC DEPARTMENTS.

The following are the chief items of mycological work carried out by other scientific departments, chiefly the Provincial Departments of Agriculture.

Madras.—The Government of Madras have issued a report on the operations for eradicating palm bud-rot in Godavari, Kistna and Malabar during the half-year ending 30th June, 1915. The method at present in force is a detailed examination of every palmyra palm in every known centre of disease, so as to detect the early stages of the attack. The diseased areas of the crown are cut out and burnt, in many cases without subsequent injury to the tree. In Kistna the total number of trees examined was 161,500, of which 0·26 per cent. were found to be dead, 0·5 per cent. had external signs of infection, and 6·2 per cent. had only internal signs visible on stripping off the outer leaves. The effect of this treatment is already visible, the total number of new infections being apparently halved as a result of the first year's work. In one holding, out of 375 trees, 247 were found to be infected and the owner had abandoned working it, because of the virulence of the disease. After treatment all recovered and when again examined the following season only 20 new cases were found. These were dealt with and it is hoped to renew working the trees shortly. In Godavari 57,835 trees were examined in certain tracts, of which 8·6 per cent. were diseased. In addition the work of cutting out dead trees was continued in the rest of the area, about 22,000 being cut. This is the lowest figure in any half-year since 1911, and is a hopeful sign that the campaign is at last beginning to tell on the disease within the infected area. It has been very fairly successful in preventing extension outside this area, but has not hitherto had any marked effect in reducing the virulence of the epidemic. In Malabar, where the coconut is chiefly attacked

and the disease is sporadic, cases have been found in 102 villages in the last two years and the total number of trees cut and burnt in the half-year was 4,428, out of 4,503 reported infected. As the number of cases is relatively small, the coconut being much more resistant than the palmyra, it is proposed to suspend the campaign in Malabar and rely on propaganda to get the people themselves to deal with the disease.

The Madras Mycologist is engaged on the study of a disease of Hevea rubber which, as already noted, seems to be identical with the "black-thread" disease of Burma. The cause has been determined to be a species of *Phytophthora*, of which the biology and life-history have been worked out. The results of the investigation will, it is hoped, be published shortly, together with a description of the parasite, which is believed to be new to science. Amongst other diseases studied by the same officer are one of paddy caused by *Ephelis Oryzæ* Syd.; a root disease of coffee associated with *Fomes australis* Fr.; a chilli disease caused by *Vermicularia Capsici* Syd., which can be prevented by spraying with weak Bordeaux Mixture; and a leaf disease of turmeric caused by *Vermicularia Curcumæ* Syd.

The Deputy Director for Planting Districts has been carrying out experiments in collaboration with the Director of Agriculture, Mysore, and the Madras Mycologist, in the treatment of the diseases of certain plantation crops. With Dr. Coleman a large measure of success has been achieved in checking black rot ("koleroga") and leaf disease of coffee by spraying with Bordeaux Mixture. The results so far obtained point to the probability of the efficacious control of these diseases, the cost, approximately Rs. 15 per acre, being by no means prohibitory, in view of the heavy monetary loss annually incurred from them. With Mr. McRae observations on the secondary leaf-fall of Hevea (believed to be due to the same parasite as that causing "black thread") have been made, and field experiments have been carried out to ascertain the cost of removing dead branches from attacked trees. The "brown blight" of tea has also been jointly studied and spraying with Bordeaux Mixture has proved successful in restoring attacked nursery plants to vigour. The parasite (*Colletotrichum Camelliæ* Mass.) has been grown in pure culture and the effect of fungicides on it tested. The recommendations for its treatment are as yet tentative, but further experience should allow of a satisfactory control of this troublesome disease. Notes on these and other diseases of tea, coffee, rubber and the like have been published in the "Planters' Chronicle."

Mysore.—Dr. Coleman's work on spraying coffee, in collaboration with Mr. Anstead, has been referred to in the last paragraph. He has also completed his investigation on "koleroga" of coffee sufficiently to allow of publication. The full paper has not yet appeared, but from a note in the Planters' Chronicle it is evident that Dr. Coleman has independently discovered the true nature of this parasite, announced some years ago by von Höhnel in Vienna from the examination of herbarium material. Von Höhnel's study was necessarily restricted from want of material and Coleman's full paper

will be awaited with interest and should throw light on a very obscure class of parasites. Other diseases of coffee are also being investigated. The measures to control the " koleroga " of the Areca palm have been described in a paper in the "Agricultural Journal of India" in April, 1915. Further work has given evidence to indicate that the disease (due to *Phytophthora Arecæ* (Colem.) Pethy.) can be definitely stamped out from isolated areas. One garden situated in an unfavourable area has had no disease for the past four years, though before treatment was adopted, it was always badly affected. During the past year it has remained untreated without getting the disease. Measures to enforce treatment are being considered which, if adopted, will enable the Department to extend these operations to a very great degree in the future. Dr. Coleman has also taken up the study of the obscure disease of the sandal-wood tree known as " spike disease," apparently an enzymatic affection. It has been definitely proved that the disease is communicable and a preliminary report will be published shortly. Other work includes studies on a *Fusarium* disease of potatoes and on mango mildew.

Bombay.—Mr. Ajrekar's work on *Rhizoctonia*, in collaboration with Mr. Shaw of Pusa, has already been referred to. He has also carried out an investigation of sugarcane smut, examining particularly the mode of infection and the effect of treatment by steeping the setts in copper sulphate solutions. The latter was found to be useless in preventing smut and injurious to the cane. A note on the work has been submitted for publication. A disease of fruit trees caused by a species of *Nectria* is under study and observations have also been made on several other diseases of cultivated plants and on the life history of a jasmine rust.

Mr. Kulkarni, Assistant Mycologist, has completed a detailed study of the smuts of jowar in Bombay, part of the work being done at Pusa. The results are not yet published, but the presence of four distinct smuts in this crop, two of which can be readily prevented, has been demonstrated. The Department is carrying out an extensive campaign against these diseases, with considerable success. Arrangements have been made with a local agency for the sale of 1 anna packets of copper sulphate, each sufficient to treat the seed for 4 acres and containing full directions for use. Some 40,000 of these packets were sold and it is calculated that, if all were properly used, a saving of about 3 lakhs of rupees to the cultivators must have resulted. As the annual loss probably exceeds a million sterling in the Presidency, and as the treatment is simple and likely to appeal to the people, the Bombay Department seems to have a very fair chance of repaying to the country in a single year more than the whole cost of the Department up to date.

In other directions the Department is also showing activities of a distinctly practical kind. The spraying of Areca palms against " koleroga," based on the work started in Mysore some years previously, is rapidly extending in the southern districts, over 9,000 having been treated, against less than 2,000 the previous year. The owners are now taking up spraying for themselves, with excellent results. Spraying grape-vine mildew has also been

taken up by the vine growers at Nasik, a recently introduced modification, which keeps the fruit free from stains, having increased the popularity of the treatment.

Central Provinces.—In this area also the smuts of jowar cause great annual loss and the copper sulphate treatment has been demonstrated with success for several years. One of the smuts appears to be less readily prevented than the commoner forms and experiments with this variety have been commenced. The loose smut of wheat is prevalent in the north of the Provinces and is difficult to check by any of the usual steeping methods. An important feature of the year's work has been the isolation of a rust-resisting cross-bred wheat.

United Provinces.—The Economic Botanist has been investigating the poppy blight prevalent in opium-producing districts and has come to the following conclusion. Of the two affections which combine to damage the crop, the root rot (due to *Rhizoctonia*) is largely dependent on cultivation conditions and where these are good the disease will not be serious. The disease caused by *Peronospora* falls in a different category and its incidence depends on the climatic conditions. The different races of poppy show great divergence in power of resistance to the disease and the best results in minimising the ravages will be found in the selection of pure races of poppy which is now in progress.

Bengal.—The work of this Department in connection with ufra disease of rice has already been referred to. Some demonstrations on spraying for potato disease were made at Rangpur and Narayanganj.

Indian Tea Association.—Mr. Tunstall, the Mycologist of this Department, has continued his investigation of the fungi which attack the roots of tea and has published the first part of a pamphlet on tea roots. A key to the identification of the root parasites, with plates, has been included. A second part of this pamphlet is in preparation. The fungi causing leaf diseases have also received attention. Grey blight has been found to be due, not to *Pestalozzia palmarum*, as often stated, but to an allied species. The brown blight fungus, *Colletotrichum Camelliæ* Mass., has been shown to be distinct from the *Glœosporium* which attacks tea leaves and stems, causing die-back. Rim-blight is still obscure, but a species of *Alternaria* is suspected to be the cause. Much time has been given to the practical questions of checking these blights and especially to spraying. The types of machines most suitable are being enquired into. Knapsack sprayers worked on the battery system by compressed air have given the best results, but a more automatic method would be an improvement and is being sought for. The Mycologist has published several notes in the Quarterly Journal of the Association.

SYSTEMATIC MYCOLOGY.

The fifth part of the series "Fungi Indiæ Orientalis" by the writer, in conjunction with Messrs. H. and P. Sydow of Berlin, has been published. It

is based on material sent to Germany before the war and was probably almost ready for press before communications were severed. It contains the first part of the collections of *Deuteromycetes* in the Pusa Herbarium, comprising the *Sphæroideæ* (173 species), *Nectrioideæ* (7 species), *Excipulaceæ* (4 species), *Leptostromataceæ* (3 species) and *Melanconiaceæ* (8 species). Seven new genera and 97 new species are described, the large proportion (nearly 50 per cent.) of new forms being an indication of the little attention previously given to this group in the East. Many of them are crop parasites but they are not, on the whole, responsible for as much damage as the mildews, rusts and smuts. A few other miscellaneous Indian fungi from previous collections have been named during the year. The writer also took an opportunity while on leave, of checking the nomenclature and establishing the identity of several Indian parasitic fungi, by comparison with the collections at Kew.

List of Publications.

ANDREWS, E. A. & TUNSTALL, A. C. Notes on the spraying of Tea. (*Indian Tea Assoc., Pamphlet, No. 1, 1915.*)

ANONYMOUS . . . Fungi Exotici, XX. (*Kew Bull. 1916, No. 3, p. 71.*)

Annual Reports of the Agricultural Research Institute, Pusa, and of Provincial Departments of Agriculture.

DASTUR, J. F. . . . A Rot of Bananas. (*Agric. Journ., India, x, 278, 1915.*)

" . Spraying for Ripe-rot of the Plantain Fruit. (*Agric. Journ., India, xi, 142, 1916.*)

" . Black-thread disease of Hevea in Burma. (*Burma Dept. Agric., Bull. No. 14 of 1916.*)

MACRAE, W. & ANSTEAD, R. D. Brown Blight of Tea (*Colletotrichum Camelliæ*). (*Planters' Chron., xi, 2, 1916.*)

MCRAE, W. & SUNDARARAMAN, S. Leaf-fall in Hevea. (*Planters' Chron., x, 452, 1915.*)

SHAW, F. J. F. & AJREKAR, S. L. The genus *Rhizoctonia* in India. (*Mem. Dept. of Agric., India, Bot. Ser. vii, No. 4, 1915.*)

SYDOW, H. & P. . . Novæ fungorum species, XIV. (*Ann. Mycol., xiv, 256 1916.*)

SYDOW, H. &. P. & BUTLER, E. J. Fungi Indiæ Orientalis. Pars. V. (*Ann. Mycol., xiv, 177, 1916.*)

TUNSTALL, A. C. . . Tea Roots, Pt. 1. (*Indian Tea Assoc. Pamphlet, No. 1, 1916.*)

" . . Fungi parasitic on the Tea plant in North-east India. (*Quarterly Journ. Ind. Tea Assoc., 1915, Pt. 3.*)

AGRICULTURAL BACTERIOLOGY.

BY

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WORK AT PUSA.

Toxins-Nitrification.—Work on the lines indicated in the report of this section for the previous year was continued, but was considerably interfered with by the claims of special enquiries on various technical subjects hereinafter dealt with. Considerable progress, however, was made in collecting evidence as to the occurrence in field soils of toxins resulting from bacterial action, and of their unfavourable influence upon fertility as dependent upon nitrification and correlated bacterial processes in soil. A series of field experimental plots under wheat demonstrated the production of infertility in soil containing nitrogenous organic matter (oilcake) as a consequence of semi-anærobic conditions artificially induced by waterlogging ; this infertility did not occur to the same extent when ammonium sulphate was substituted for cake, nor did the effect of the waterlogging become apparent until the roots of the plants had gone down some inches, to that level in the soil which oxidation consequent on the cultivation, had failed to reach. Parallel plots with barley illustrated this effect more markedly than those with wheat, no doubt owing to the later formation of the secondary root system in the former crop and its consequent dependence for a longer period of its early growth upon the original deeper roots. Laboratory work on nitrification and on the growth of seedlings in water and soil cultures demonstrated the possibility of separating substances from certain bacterial cultures, from decomposing organic matter and from anærobically incubated soil, whose toxicity to nitrifiers, and in greater concentration to seedling plants was demonstrable under these conditions.

Interesting observations were made as to the interference with the growth of seedlings resulting from the bacterial invasion of the unexhausted and still attached seed and the consequent absorption by the plant of toxic bacterial byproducts. This invasion occurred most readily in waterlogged soil and more especially in the presence of the bacteria derived from anærobically incubated soils of high organic matter content. Copper sulphate was found to neutralize most of the toxic bodies obtained in this way, and seeds treated with this salt were found to be immunized to some extent, although not entirely or invariably, against this action. It is suggested that some such treatment might be advantageous when sowing in wet soils, although the results of field trials have so far

not yielded conclusive results, owing to the difficulties associated with its use and the unfavourable effect upon germination which copper sulphate has been found to exert in many instances.

Among soil toxins produced by bacterial action nitrites are well known to exert a prejudicial effect upon plant growth ; it has been found that their presence in soil is not alone due to the reduction of nitrates already formed although this is of frequent occurrence, but that in many of the soils examined in this laboratory nitrites accumulate to some extent before nitrate formation becomes evident, even under conditions apparently favourable to nitrification. It is not clear at present whether this is due to the formation and reduction of nitrates or to incomplete oxidation consequent on the lack of activity or insufficient number of nitrate formers in the soil. Evidence is not wanting that in many of the soils examined the very slow rate of nitrification observed under optimal conditions of æration and water content, is due to the absence in sufficient numbers or lack of physiological activity of the necessary nitrifying organisms. It will be readily realized what an important field for enquiry is opened up by this observation, which, however, in view of its wide divergence from received ideas on this subject, will require further substantiation by careful experiment and observation. The effect of nitrites on seedlings and the concentration required to produce the prejudicial results observed, was ascertained for various field crops in water culture. At the same time observations were made as to the concentration of nitrites occurring in the soil water under various conditions, but in none of the soils examined was this found to rise to the degree found toxic in water culture. It does not necessarily follow that this statical treatment of the question disposes of the possible intoxication by nitrites of plants growing in such soils, owing to the necessity for taking into account the constant formation of nitrites in the soil to replace those absorbed by the plant or oxidized in the soil, and the possibility of cumulative intoxication in the plant itself of which at present we know nothing. The presence of nitrites in soil was found to affect germination and early growth ; this explained the apparently anomalous result of an experiment in which germination in a well ærated soil compared unfavourably with that in the same soil badly supplied with air ; on further examination it was found that in this soil when well ærated, complete nitrification was preceded by the incomplete stage of nitrite formation and accumulation, and as this was coincident with the germination period of the seeds sown therein the germination of the latter was interfered with to a greater extent than in the soil in which no nitrification was taking place.

Weekly borings and nitrate determinations throughout the year were made in three sets of duplicate plots under grass, cold weather and rains crops (wheat and maize), and fallow respectively. Only in the last of these was there any accumulation of nitrate in the first foot of soil, a much smaller amount occurring in the cropped soil and only very small quantities under grass. Experiments will be made to ascertain whether the grass effect is due to interference with the upward movement of water resulting from the checked evaporation from

the surface, to lack of æration, or possibly to the toxic action of the specific bacterial flora associated with the grass plants. The nitrate accumulation was highest in February and reached a minimum in August ; this was only in the first foot of soil and no doubt represented the vertical movement of nitrates parallel with that of the soil water.

Green manuring—Experiments with fermented green manure were carried out on tobacco to which fermented sann hemp (*Crotalaria juncea*) was applied. Very large increases in yield were obtained, and a bulletin (No. 63) describing this modified method of manuring was published, inviting suggestions and criticisms from agricultural officers in the Provinces from whom many useful and appreciative communications have been received, pointing out the applicability of the method to various manurial problems and special cases in their several districts. It is hoped that the experimental trials of this method which are now being made throughout India may lead to more satisfactory and certain results from the use of green manures than are generally obtained. A field trial of the method at Pusa carried out by the Imperial Agriculturist on the *rabi* oat crop gave very high returns ; the Officiating Imperial Agriculturist is carrying out a further experiment this year.

Saltpetre.—The inquiry into the conditions favouring the occurrence of saltpetre in Indian soils and the methods adopted by the native for extracting it, was continued and the results published in a Bulletin.

It was concluded that the output of saltpetre is limited at present not so much by the available supply of raw material, as by the number of workers (*Nuniahs*) actually engaged in extraction, this being largely determined by the price of crude saltpetre and the restrictions imposed by landholders, refiners, and the Salt Department. No special soil organisms appear to be associated with saltpetre deposits which are the result of the nitrification of organic matter accumulated in the neighbourhood of human dwellings, the high concentrations of nitrate found in the soil in such sites being due to the upward movement of water carrying dissolved nitrates to the surface where they become concentrated by the intense evaporation going on during the dry months of the year. Experiments on a field scale showed the feasibility of adding to the store of nitrates in the country by the use of nitre beds made up by burying a green crop, in this case *crotalaria juncea*, in ordinary field soil and compacting the heaps sufficiently to ensure the capillary rise of water from the subsoil to the surface, where the nitrates formed accumulates and can be scraped off after the manner of the *nuniah*. It is suggested that a very large output of saltpetre could be obtained in this way in those parts of India in which soils with sufficient lime content and suitable physical texture are found. At the same time the condition of the industry as a whole could be greatly improved by the introduction of better relations between the *nuniah* and refiner and a revision of the rules of the Salt Department in regard to both of them. It seems clear that the profits of the trade are not equitably divided between the *nuniah* and the refiner, the former class, in consequence of its poverty and lack of business capacity being entirely at the mercy of the middle

man or refiner to the detriment of the industry as a whole. So far as the methods of extraction and refining are concerned the work of the Chemical section of this Institute as described in Bulletin No. 24 by Messrs. Leather and Mukherji has demonstrated the possibility of great improvement in the refining part of the process, and further investigation in the writer's laboratory has shown that the *nuniahs* method of extraction of the crude saltpetre is far from being economically sound, and could be greatly improved upon by some simple variation of his present technique, which would, however, probably depend upon co-operation with the Salt Department in order to avoid infringement of the regulations at present in force. An advantage offered by the artificial method of producing saltpetre above referred to, lies in the comparative freedom from contamination by salt (sodium chloride) of the crude saltpetre resulting from this method, thus avoiding to a great extent in the process of extraction the restrictions necessarily imposed upon this process by excise requirements, with a consequently higher return of pure product to the advantage of the *nuniah* and the trade.

Fermentation organisms.—Further work on alcohol producing organisms, and upon various problems in connection with Indian distilleries was carried out at the request of the Departments of Excise in Bengal, Bihar and Orissa, Assam and Central India, and of private firms in various parts of India. Improved methods of obtaining and utilizing yeast cultures of indigenous origin were experimented with and gave promising results. The use of mixed cultures of good types of S. cerevisiæ of Indian origin was reported by the Commissioner of Excise for Central India to have given an increased yield of some 20 per cent. in the Nowgong Distillery, and the method of reinoculation devised in this laboratory was found to give considerably higher yields of alcohol in the same period of time and should therefore be of value in avoiding the evil effects of the acetic fermentation which generally sets in towards the end of the process.

Numerous other problems connected with other fermentation were studied, but it is clear that a good case exists for the establishment of a special laboratory in India for the investigation of such questions, both for the isolation of good strains of yeast and for the training of distillers' assistants in their proper use.

Pebrine.—At the request of Mr. Lefroy, Imperial Silk Specialist, an investigation of the conditions of incidence of this disease of silkworms in India was undertaken. The primary object of the enquiry was to determine whether the failure to avoid disease in India by using the Pasteur method of selection of disease free "seed" is due to any inherent inapplicability of the method to Indian conditions, or merely to its improper use in this country. So far as the enquiry has proceeded it appears that both these factors come into play in Bihar and Bengal. The Pasteur method depends upon the examination of the parent moth and the rejection of eggs from those found infected; the standard method of examination devised by Pasteur and used with success

in Europe but with less certainty in India, allows of microscopic examination of a drop of the fluid obtained by crushing the whole moth without distinction of parts, it being assumed that the disease-producing *pebrine bodies* will exist in such numbers in the diseased insect at this stage of its growth as to make certain of their occurrence in any sample of the body fluids taken for examination. This, however, has not been found to be the case with the pebrine infected moth of the multivoltine mulberry silkworms as used in this part of India. Examination in the ordinary manner in many cases has failed to find the pebrine bodies, whereas examination of the lining tissues of the intestine of the same specimens has revealed their presence, the diseased condition being subsequently confirmed by the development of pebrine in a high percentage of the larvæ reared from the eggs of the moths so affected. It is clear therefore that in India the standard method of examination fails to eliminate all diseased eggs, and in order to be at all certain of this being done it will be necessary to alter the method and unfortunately to make it more difficult and laborious, although not at all outside the range of capability of the class of workers at present engaged in selection. In parts of Bengal the conditions are rendered more difficult by the unalterable prejudice of the rearers against purchasing "seed" in the form of eggs, their desire to be assured of the quality of the silk to be obtained leading them to refuse to buy anything except live "seed" cocoons. This means that eggs derived from moths which have passed examination and are presumably disease free, must be hatched out and brought to maturity, at the same time going through all the chances of infection incidental to several weeks life in artificial surroundings, the resulting cocoons, possibly reinfected during maturation, being bought by the rearers and used as seed. Until this prejudice is overcome by the establishment amongst the rearers of more confidence in the rearing stations, the industry must necessarily labour under the disadvantages resulting from the chances of reinfection of the seed in the manner above described.

A further point of interest has been investigated and sufficient evidence collected to warrant a certain amount of confidence in the conclusion arrived at, namely that infection of the larvæ so far as Pebrine is concerned does not take place at all after the third moult, with difficulty after the second moult, but with comparative ease up to this stage in the life cycle. This conclusion is necessarily only a provisional one being based on a comparatively small number of experiments, but should it be confirmed by further observation it will simplify the precautionary measures in rearing by making it possible to relax them considerably during the later stages of growth, when larger quantities of leaf and greater space are required by the worms. Incidentally it was found that the majority of the larvæ were not only able to resist infection altogether when kept under optimal conditions so far as space, air and food were concerned, but that in a large number of cases the progeny of highly pebrinized moths failed to develop disease at all, if reared under these favourable conditions, others from the same brood but in unfavourable surrounding succumbing in large numbers.

Study of the life cycle of the parasitic organism (Nosema Bombycis) is being carried out; so far no marked difference have been observed between the Indian and European forms, but observations are necessarily incomplete at present.

Indigo.—At the suggestion of the Indigo Chemist an enquiry was undertaken into the bacteriological aspects of the fermentation taking place in the indigo steeping vat. As might have been expected, many important facts in connection with the great variations in yield which are known to occur for no obvious reason were brought to light by this enquiry, which, however, has not yet proceeded far enough to afford any complete explanation of the results obtained. It is clear, however, that the success of manufacture as at present carried out depends primarily upon the presence and action of specific bacteria in the steeping vat, and further that in some cases an adverse result is due to the activity and deleterious influence of others. It is a well-known fact that during the earlier days of manufacture the yield of indigo is low but becomes rather suddenly higher, remaining so as long as continued use of the vats persists. Any vats not utilized at first but brought into operation later, exhibit the same phenomenon, clearly showing that the latter is not due to changes in the plant, the water, or methods of manufacture. Well attested cases have been observed of differences in yield of as much as one hundred per cent. or more between head factories and their out-works manufacturing plant grown under similar conditions of soil and climate, and it was possible in one instance to arrange to exchange indigo plant from one such factory to another thus eliminating any possible influence of this factor, but without altering the previously observed differences in the respective yields. The most obvious conclusion seems to be that such differences are due to the presence or absence of specific bacteria which multiply in and infect the steeping vats, increasing in number and consequently in their influence upon the character of the fermentation up to the limits of the permanent substratum (in this case the walls and floor of the vat) upon which they remain from one operation until the next; this supposition is supported by observation of the easily verified fact that fermentation commences in the immediate neighbourhood of the walls of the vat and gradually spreads therefrom towards the centre. Here we have an analogy which such functions as that of the "starter" in dairy work and the bacterial slime of the sewage filter bed, and very probably under natural conditions with the micro-organisms responsible for the retting of jute and flax. Many industries depend upon the intervention of micro-organisms, but whereas in some of them the presence of desirable species and the absence of deleterious ones is ensured by artificial measures as in the case of brewing and distilling, in others it is assumed that the proper organisms will be naturally present in sufficient predominance to ensure satisfactory results. This is the case with such nâtive Indian industries as the fermentation of "Toddy" and "mahua" the retting of jute and the steeping of indigo, but it is becoming daily more clear that the distribution of the necessary and proper micro-organisms is by no means so universal or so fortunate as to carry

these and similar operations outside the range of practical artificial regulation.

The inquiry in connection with indigo is at present in too early a stage to warrant any confident assumption that it will be possible to apply the methods of the distillery or the dairy with economic success to a raw material, such as the indigo plant, but should further work confirm the conclusions set forth above, it would appear that very considerable improvements in the methods of manufacture may be obtained by artificially ensuring the presence of the necessary organisms in the steeping vat.

It has been ascertained that two distinct types of fermentation may be found in the steeping vats, one in which copious evolution of nitrogen takes place the only other gas given off being carbon dioxide, and the other in which hydrogen is liberated in addition to these two. In the former case, during the factory period of fermentation, about twelve hours, nitrogen forms sometimes as much as 98 per cent. of the evolved gases the remainder being carbon dioxide ; later these proportions are slowly reversed, but this reversal is of no importance as not affecting factory conditions and requiring 48 hours to 60 hours to complete.

In the second case the evolved gases after twelve hours are composed of about equal parts, some 33 per cent. each of nitrogen, hydrogen, and carbon dioxide. It is remarkable that no trace of methane has been found in any of the numerous fermentations carried out, and it is also of great interest to note that in some instances in contradistinction to the high nitrogen evolution frequently found, very small quantities of this gas were evolved.

It is clear therefore that the character of the fermentation must be governed by that of the bacterial complex fortuitously present, and that this may vary essentially and profoundly even in contiguous localities. This variation will have a special interest and importance in connection with the decomposition of organic matter in soil under varying conditions, and must be taken into careful consideration in advancing any theories based upon observation of chemical changes due to bacterial action in soils under otherwise apparently similar conditions.

Numerous species of bacteria have been isolated in the course of this enquiry and their physiological activities with regard to the processes of fermentation investigated. It has been possible to place some of them definitely, either in the class of beneficial or deleterious organisms, but much further work will have to be done before their true functions in this connection are fully understood. It is of interest to note that one bacterium has been identified with the unfortunate condition which sometimes arises in the "beating" or oxidizing process known as "green vat."

Biological analysis of soils.—Numerous samples of soil from various districts were analysed by the biological method elaborated in this laboratory. Familiarization with the use of this method forms an important part of the training of students in this section and as such students mostly come from the

laboratories of Provincial Agricultural Colleges and return there as assistants to the experts engaged in soil investigation, it is hoped that in course of time the method may be adopted as a standard part of such enquiries throughout India.

WORK IN THE PROVINCES.

Madras.

Messrs. Harrison and Aiyar continued their researches on the fermentation phenomena of paddy soils, in connection with which they published as a Memoir of the Department of Agriculture, a study of the physiological and cultural characters of a new hydrogen oxidizing bacterium, the presence of which together with its functions in the surface film were described in a previous memoir by the same authors. It is readily distinguished by its morphological and cultural characters from Kaserer's B. pantotrophus and especially by its specific hydrogen oxidizing power in presence of soluble organic matter which enables it to perform this function in the natural surroundings in which it has been found by the authors, in which B. pantotrophus could not carry out this oxidation. Its importance, as a means of conserving some of the energy which would otherwise be lost with the dissipation of the hydrogen gas, is pointed out.

Further work on soil gases was carried out during the year by Dr. Harrison, who concludes that a considerable proportion of the gases evolved from swamp paddy soils are held and prevented from escaping directly into the air by the matted roots of the crop, thus enabling them to play a more extensive part in the indirect oxygen supply to the growing plants described in the memoir dealing with this subject.

Dr. Harrison has come to the conclusion that as a consequence of the large percentage of nitrogen liberated as gas from the fermentation of green manures in paddy soils under swamp conditions the value of such manures as suppliers of nitrogen to the rice crop is very small, their beneficial action probably being limited to the indirect æration effect which he has described.

Punjab.

Work on Alkali soils was continued in the laboratory of the Agricultural Chemist.

It was found that excessive washing of alkali soils resulted in the loss of nitrifying power, the nitrifying organisms being still present but in an inactive condition. This was correlated with the removal of potash and phosphates as a consequence of excessive washing.

Nitrogen fixing organisms were not found in these soils at a greater depth than six inches, whereas both nitrifying and ammonifying bacteria were present at a depth of nine feet.

Publications.

HARRISON, W. H. & SUBRAMANIA AIYAR, P. A. .	The Gases of Swamp Rice Soils, Part III.—A Hydrogen Oxidizing Bacterium from these soils. (*Mem. Dept. Agr., India, Chem. Ser. iv, No. 4*).
HUTCHINSON, C. M. .	Saltpetre.—The conditions under which it is formed in Indian soils.
" " .	A modified method of Green Manuring. (*Pusa Agrl. Res. Inst. Bul. No. 63*).
" " .	Annual Report of the Imperial Agricultural Bacteriologist for 1914-15.

FORESTRY.

I. SILVICULTURE.

BY

EDWARD MARSDEN,

Silviculturist.

Statistical work in typical forest crops.—The establishment of permanent sample plots in typical forest crops with the object of ascertaining the rate of growth under different conditions and of ultimately framing yield tables was continued in the Central Provinces and in the United Provinces. The first sample plots were laid out in 1910-11, and 50 plots have been remeasured this year. The effect of different methods of thinning as well of different degrees of severity in thinning can be studied only by means of permanent plots which are remeasured periodically. Opinion is by no means unanimous upon the principles to be observed in the practice of thinning pure crops at various stages in their life. Besides age and locality, the silvicultural character of the species exercises a modifying influence; and in a given locality where several crops of the same age are present, an opportunity is afforded for studying the effect upon the growth of the crop produced by thinning carried out in calculated degrees of severity, based upon what is known of the silviculture of the species. For *Pinus longifolia* in Kumaon 4 crops were left unthinned and 4 crops were thinned in 1911-12.

The remeasurement of these 8 crops this year indicates that the thinned crops grow considerably faster, the average girth for 50 years of age being in the one case 20″ as compared with 17″, and at 70 years, 31″ as compared with 25″. This proves the correctness of the general opinion that *Pinus longifolia* benefits markedly by thinning; but the optimum density for any age in a given locality remains undecided, and even an approximation to the truth can be found only from the comparison of numerous measurements extending over a long time.

Such results as have been obtained indicate that it is far more important to ascertain the effect of tending in different ways than to determine what the rate of growth may be under existing conditions.

In addition to remeasuring fifty of the existing plots, thirty-one new permanent sample plots were laid out during the year in crops of *Shorea obusta* and *Pinus longifolia*, and one in *Cinnamomum Camphora*.

Since 1910-11, when this branch of investigation was started, 219 permanent sample plots have been established; of these 143 are in the United

Provinces, 47 in the Punjab, 11 in Bengal, 15 in the Central Provinces, and 3 in the Forest Research Institute experimental garden at Dehra Dun.

The Sal tree (Shorea robusta).—Under the prescriptions of the Board of Forestry the Sal tree is the species whose silviculture is to be specially studied. Considerable progress has been made in the compilation of statistics relating to this tree. Such of these as deal with rate of growth go to show that except where local conditions are particularly favourable its growth in girth is slow or very slow; and it is hoped that experiments in different methods of tending as expressed in the permanent sample plots will give us hints upon which it may be possible to base some methodical scheme of tending leading to an acceleration in growth. There is reason to presume that in the past the advantages to be derived from tending Sal crops have not always been fully recognised; but the best method of tending must remain for some time a matter for experimental research. A tour was made in the Sal forests of Mandla and Balaghat districts in the Central Provinces; statistics were collected and observations recorded on the unsatisfactory state of natural regeneration. In this locality it seems possible that the high proportion of iron in the soil produces a condition not at all conducive to the early establishment of Sal seedlings. The rate of growth is astonishingly slow, but to what extent this is due to locality and whether adequate tending may be able to counteract the factors operating is a matter for experiment. Plots were laid out in the endeavour to obtain natural reproduction by means of soil-preparation and various modifications in the degree and distribution of shelter. Where the climate is dry and extremes of temperature are therefore common, the necessity of combining shelter with access to plenty of light presents difficulties which in this locality are accentuated by the peculiar condition of the soil.

Polyporus shoreæ was found attacking Sal trees in the Central Provinces; hitherto this fungus had not been reported from the Central Provinces.

An illuminating article on the natural reproduction of Sal was published by Mr. R. S. Hole in the "Indian Forester" XLI—351, summarizing the results of experiments and drawing conclusions.

The Silvicultural Garden.—Experiments in reproduction, both natural and artificial, are being continued; root-pruning and stem-pruning has been proved to assist certain species to withstand the shock of transplanting. Winter transplanting is under study both for plants and for cuttings. The effect of working the soil to different depths in the cold weather and just before the rains is being investigated. Several different methods of growing Sal with nurses form the subject of special experiments. The raising of tree-crops in combination with agriculture continues to give interesting results.

It is hoped that before very long it may be possible to apply on a large scale in the forest the conclusions drawn from experiments conducted in the garden. Sufficient experience has been acquired to enable us to avoid some of the pit-falls awaiting attempts to restock large grassy blanks, but conditions in the forest are so different from those in a garden that further experi-

ments in the forest are very necessary before methods can be recommended as generally applicable.

Developments in Silvicultural Systems.—Considerable progress has been made this year in the introduction of improved silvicultural systems. With a small and untrained staff the pioneers of forestry in India had to confine their energies to reservation, demarcation, and conservancy. Checks were provided against over-cutting while a regular outturn was rendered available for the timber industry. Revenue fellings disguised under the euphemism of "the Selection System" were the rule, while the "proportionate representation of the age-classes" and the "maintenance of the yield" formed the shibboleths of the day. Little attempt was made to establish the normal increment, and the problem of regeneration though always recognised as important was considered for the time being beyond the region of practical politics. And indeed with the sketchy and scattered information available upon the silviculture of Indian trees things could not well be otherwise.

Mr. Jerram's 1915 working plan for the *Pinus longifolia* forests of Rawalpindi is founded on the attainment of the normal forest and on the complete regeneration of a given area within a definite time. It recognises the principle of concentrated regeneration based on the silvicultural character of the species dealt with. If one disregards the artificial Teak plantations of Burma, the late Mr. Joseph Messer was perhaps the first to try and apply these principles. For several years he conducted experiments in the concentrated natural regeneration of Teak in Katha Division, and his efforts culminated in the preliminary working-plan report for Mohnyin Reserve drawn up in 1907 by the Chief Conservator of Forests. This developed into the 1911 Mohnyin Working-plan by H. R. Blanford, which may be considered the first of the Indian working-plans to adopt the concentrated natural regeneration of a single species. Of the *working-plans* published during the year Mr. S. F. Hopwood's plan for the Thingadon Yama and Patolon Working Circles, Burma, prescribes the method of Improvement Fellings for a Teak forest. This is a departure from previous methods in Burma, and to this extent it is an advance, but so long an interval as ten years between such fellings for the benefit of young Teak is open to criticism.

Several other important papers have appeared this year dealing with silviculture generally or with particular species.

The Inspector General of Forests' Note on the Sal forests in the Jalpaiguri, Buxa and Goalpara Divisions to which is appended a Note by R. S. Troup on the Forests of the Duars introduces a new era in the management of Sal forests. Artificial regeneration for Sal in combination with agriculture is recommended for trial, and the whole question of Sal reproduction and fire protection in this locality is investigated in detail.

Mr. C. G. Trevor's paper on the Deodar read before the 1915 Punjab Forest Conference is the most complete source of information about this species and gives the results of experiments in reproduction carried out by the author

over a series of years. It was hailed in America as the best silvicultural paper published in the "Indian Forester" for many years.

Mr. R. S. Troup's Note on some European Silvicultural Systems with Suggestions for Improvements in Indian Forest Management indicates the lines upon which methods of treatment should be based, gives examples of the way in which natural regeneration has been successfully obtained after a study of the locality and of the species, and throws light upon the measures which might be taken in India to introduce more rational systems of management.

The Inspection Notes published by the Inspector-General of Forests during the year contain much of great silvicultural importance. In place of general advice, detailed suggestions are made for dealing with local problems.

"*Pinus longifolia Roxb.*—A sylvicultural study," by R. S. Troup, was published at the close of the forest year. This monograph of 126 pages with 33 plates constitutes the first volume in the Sylviculture Series of the Indian Forest Memoirs. It is the first book published in India, dealing scientifically with the silviculture of a single tree, and appears appropriately enough in the same year as marks the introduction of concentration regeneration as a principle in Indian methods of treatment.

It will be evident that a considerable impetus has been given to the study of silviculture in India, and definite progress has been made. No previous year can show anything like such an output of literature on the subject. A new standard has been set up, and if the same quality is maintained in the future the whole department will receive a stimulus whose effect upon forest management in India is likely to be shown in the development of novel silvicultural systems adapted to each important species and to the peculiarities of varying localities.

List of Indian Publications during 1915-16.

BAKER, J. L. . . . Working-plan of the Andamans Forest Division, Andamans.

BELL, T. R. . . . Method of measuring timber. (*Ind. For., xlii, 159.*)

BEST, HON'BLE JAMES W. Improvement Fellings. (*Ind. For., xli, 499.*)

CANNING, F. . . . A method of marking trees in enumerations. (*Ind. For., xlii, 312.*)

COVENTRY, B. O. . The Jhand (*Prosopis spicigera*) Forests of the Punjab. (*Ind. For., xli, 307.*)

" . . . The Olive (*Olea cuspidata*) Forests of the Punjab. (*Ind. For., xli, 391.*)

EDIE, A. G. . . . Thinnings of Teak Coppice in Kanara. (*Ind. For., xlii, 157.*)

GARUDACHELLAM, C. P. An experimental area of *Hopea parviflora*. (*Ind. For., xlii, 247.*)

GONSALVES, A. F. . Working-plan for the Teak and mixed Sub-Ghat Forests of the Lanavla and Ambegaon Ranges in the Poona Division, Bombay Presidency.

HART, G. S. . . . Inspection Note on some of the Forests of Assam.

" . . . Inspection Note on the Kulu and Kangra Forest Division, Punjab.

" Inspection Note on the Forests of Coorg.

" Inspection Note on the Forests of the Eastern Circle, United Provinces.

HART, G. S. & TROUP, R. S. Note on the Sal forests in the Jalpaiguri, Buxa and Goalpara Forest Divisions to which is appended a Note on the Forests of the Duars.

HODGSON, E. M. . Revised working-plan for Nagargali Series XIX Khanapur Taluka, Belgaum District, Bombay Presidency.

" . . . System of sale of standing trees in Kanara. (*Ind. For., xlii, 313.*)

HOLE, R. S. . . . Teak Reproduction as a result of clear felling. (*Ind. For., xlii, 51.*)

" . . . The Natural Reproduction of Sal and how it can be improved. (*Ind. For., xli, 351.*)

HOPWOOD, S. F.. . Working-plan for the Thingadon-Yama and Patolon working circles in the Lower Chindwin Forest Division, Northern Circle, Upper Burma.

HOWARD, S. H. . . A Classification of Thinnings and Increment Fellings. (*Ind. For., xlii, 66.*)

" . . . . The calculation of an approximate financial rotation. (*Ind. For., xlii, 72.*)

HUNT, A. . . . . Working-plan for the Akola Forest Division, Berar Circle, Central Provinces.

JERRAM, M. R. K. . Revised Working-plan for the Forests of the Murree and Kahuta Ranges, Rawalpindi Division, Punjab.

KOPPIKAR, T. N. . Reboisement of blanks in forests. (*Ind. For., xlii, 164.*)

LUSHINGTON, P. M. . Note on Spike Disease in Sandal. (*Ind. For., xlii, 61.*)

M. K. G, ... Sandalwood—Its Parasitic Habit. (*Ind. For., xlii, 33.*)

MARSDEN, EDWARD . Reproduction of Teak by root-suckers. (*Ind. For., xlii, 43.*)

MILLER, W. A. . . Working-plan for Block VII-A., Southern Circle, Bombay Presidency.

" . . Working-plan for the Chandavar Forests in the Western Division, Kanara, for the fuel supply of Kumta Town, Bombay Presidency.

MILLETT, G. P. . . Working-plan for the Transpurana Babul forests of the Edlabad Range of the East Khandesh Division, Bombay Presidency.

" . . Working-plan of the Mixed Junglewood and Evergreen Forests of the Mulshi Range, Poona Division, Bombay Presidency.

MORGAN, V. G. . . Working-plan for the forests of the Chindwara Division, Northern Circle, Central Provinces.

NARASINGA RAO, M. . Coppice with Standards in the Central Provinces and the effects of drip and shade upon coppice. (*Ind. For., xlii, 23.*)

NAVANI, D. J. . . Revised working-plan for the Jerruck Forest Division, Sind Circle, Bombay Presidency.

PARKER, R. N. . . Meteorological Observations at Changa Manga. (*Ind. For., xli, 220.*)

RODGER, A. . . The Myodwin Teak Plantations, Zigon Division, Lower Burma. (*Ind. For., xli, 372.*)

SAIYID ABDUL QADIR *Pterocarpus santalinus* (Red Sanders) Reproduction, Germination and Growth of Seedlings. (*Ind. For., xlii, 27.*)

SHRINIVASULU NAYADU, S. The habits of *Pterocarpus Marsupium* .(*Ind. For., xlii, 287.*)

SMYTHIES, E. A. . Some financial aspects of resin-tapping in chir-pine forests. (*Ind. For. xlii, 187.*)

" . . Thinnings and Cleanings. (*Ind. For., xlii, 315.*)

TRAFFORD, F. . . The Mound and Pit method of planting (*Ind. For., xlii, 261.*)

TREVOR, C. G. . . The Deodar. (*Ind. For., xli, 439.*)

TROUP, R. S. . . A Note on some European Sylvicultural Systems with Suggestions for Improvements in Indian Forest Management.

" . . A Note on the Cultivation of *Podophyllum Emodi.* (*Ind. For., xli, 361.*)

" . . *Pinus longifolia*, Roxb. A Sylvicultural Study, (*Indian Forest Memoirs, Sylviculture Series, Vol. I, Part I.*)

TROUP, R. S. & HART, G. S. Note on the Sal forests in the Jalpaiguri, Buxa and Goalpara Forest Divisions to which is appended a Note on the Forests of the Duars.

TROUP, R. S. . . The Natural Reproduction of Sal. (*Ind. For., xlii, 57.*)

WALKER, H. C. . . The Uniform System in Burma. (*Ind. For., xlii, 201.*)

" . . . Working-plans in Burma. (*Ind. For., xlii, 108.*)

WATSON, H. W. A. . Teak Working-plans in Burma. (*Ind. For., xlii, 1.*)

WHITEHEAD, T. A. . A possible cause of "Spike" in Sandal. (*Ind. For., xlii, 243.*)

WOOD. B. R. . . Increment Fellings with some possible applications to the chir pine. (*Ind. For., xlii, 283.*)

II.—ECONOMIC FOREST PRODUCTS.

BY

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Forest Economist.

Economic uses of Deodar Timber.—The enquiry on this subject is being conducted under the following heads :—

(i) *Rate of seasoning and mechanical tests of strength.*—A large number of logs felled at various times of the year, in different localities were laid down to season. On the moisture percentage falling below 15 per cent. the logs were converted into scantlings and subjected to tests for Transverse, Shear and Compression strain, both at Dehra Dun and at the Sibpur Engineering College. The results show that the season at which the timber is felled has no effect on its strength. Twenty tests for transverse strain on deodar timber obtained from the Chakrata Division, United Provinces showed its strength to be 4·57 tons per square inch, while 60 tests on timber from the Bashahr and Kulu Divisions of the Punjab, showed the transverse strength of this timber to be 4·65 tons per square inch. To withstand compression strain the United Provinces timber showed an average of 2·48 tons per square inch, being the average of 20 tests, and the Punjab timber 2·43 tons per square inch, being the average of 60 tests. For shearing strain the figures arrived at were 5·32 and 5·38 tons per square inch for the United Provinces and Punjab Deodar respectively.

(ii) *Resistance to pull on dog spikes.*—Spike pulling tests are virtually tests for toughness. They were carried out on a variety of timbers besides Deodar, and were undertaken at the instigation of the Railway Authorities. The results of tests carried out on Deodar sleepers showed that it required 4,315 lbs., 3,791 lbs. and 2,770 lbs direct pull to release spikes driven into $\frac{3}{8}''$, $\frac{1}{2}''$ and $\frac{5}{8}''$ holes respectively. When the holes were bored to the depth of $1\frac{1}{2}''$ with $\frac{3}{8}''$, $\frac{1}{2}''$ and $\frac{5}{8}''$ augurs and not right through the sleeper, the dog spike in both cases being driven home, the pulls required were 3,807 lbs., 3,959 lbs. and 3,709 lbs. respectively. From these experiments it is clear that the best results are obtained with a $\frac{3}{8}''$ hole bored right through the sleeper. It is interesting to note that the pull required to release a dog spike from Sāl (*Shorea robusta*), driven into a $\frac{3}{8}''$ hole, bored

right through the sleeper was 5,315 lbs., or exactly 1,000 lbs. more than in the case of Deodar.

Grasses for Paper Pulp.—The United Provinces Government sent home 25 tons of "Ulla" grass (*Anthistiria gigantea*) to be tested in England, the final report on which is awaited.

The writer proceeded to Assam to inspect a selected grass area, situated between the Monas and Brahmaputra rivers. The yield of air dried grass, based on sample plots, was found to be 7·8 tons per acre in the case of *Saccharum spontaneum*, 3·5 tons per acre for *Saccharum Narenga* and 8·04 tons per acre for *Phragmites Karka*. Many thousands of acres of these types of grass lands occur in this locality, so that the total annual yield is very large. The cost of extraction is not prohibitive, while the labour supply is barely sufficient. Twenty tons of each of *Saccharum spontaneum* and *Saccharum Narenga* grass were sent to a Calcutta Paper Mill to be tested. The results were quite satisfactory, especially with stalks of *Saccharum spontaneum*, while the leafy heads of both species mixed together, produced paper of the class of "Badamis" or "Browns" and did not bleach satisfactorily.

Utilization of Bamboo Pulp.—Mr. Raitt has prosecuted his enquiries during the year to perfect his methods of treating bamboos and elephant grasses by his fractional digestion method. His investigations are still in progress.

Samples of *Dendrocalamus strictus* bamboo were sent by the Mysore Durbar to a Calcutta firm of Paper Makers to be tested, the results obtained being very satisfactory.

Interest is being taken in Bombay as to the possibility of starting a pulp factory working *Bambusa arundinacea* on the West Coast, and in this connection the writer gave evidence before and supplied all necessary information asked for by the Indigenous Industries Committee appointed by the Bombay Government.

A well known firm of Edinburgh pulp manufacturers, having worked at the question of pulping bamboos for several years, now claim to be able to obtain excellent results by treating bamboos by a modified sulphide process. In order to test the accuracy of this assertion arrangements have been made to send 5 tons of *Bambusa polymorpha* home to be tested by this process.

An experiment of considerable value was started in the Myitkyina Division of Upper Burma in 1912, to ascertain the effect of cropping bamboos at stated intervals, in connection with the extraction of bomboos for paper pulp. The sample plots were carefully redemarcated and recounted this year by Mr. J. V. Young, Deputy Conservator of Forests. The results so far indicate the possibility of cropping bamboos on a short rotation without seriously affecting the sustained yield.

Match Industry.—In last year's report it was pointed out that the solution to the difficulty of finding an entirely suitable timber for match splints

was bound up with that of finding a cheap means of extracting Spruce (*Picea Morinda*) and Silver fir (*Abies Pindrow*) timber from the hill forests. The solution probably lies in mechanical traction and the erection of portable splint-making machines. As neither of these are available in war time the enquiry is at a standstill.

Antiseptic Treatment of Timber.—The experimental sample plot at Dehra Dun in which twelve species of timber treated with a large variety of different antiseptics have been placed in the ground side by side with untreated specimens, was maintained and the condition of each stake recorded from time to time. Up to date antiseptic oils have given better results than salts, while creosote oils have given better results than petroleum oils.

The experimental sleepers treated between 1910 and 1915, and which were afterwards laid in the open line, were inspected either by the Railway Authorities or the writer, while those laid in the Burma Railways, amounting to about 3,000 sleepers in all, were inspected by Mr. A. Rodger, Research Officer, Burma. Those that have been longest in the line are the Powellized sleepers laid down in 1911. Where defects have had to be recorded in the various reports, they invariably refer to cracking of the timber and not to the deterioration of the fibre. The tendency of certain timbers under experiment to crack is noticeable, though to date it has not been of a sufficiently serious nature to necessitate the rejection of more than one to two per cent. of the total number of each species laid down.

A few sleepers of each of eight species of timbers were sent to England to be treated by the Rüping process. The results showed that *Dipterocarpus turbinatus*, *Dipterocarpus pilosus* and *Dipterocarpus alatus* timbers absorbed over 7 lbs. per cubic foot, *Terminalia myriocarpa* and *Pinus longifolia* timber absorbed between 4 lbs. and 5 lbs. per cubic foot and that *Terminalia tomentosa*, *Terminalia Manii* and *Dipterocarpus tuberculatus* timbers absorbed between 2 lbs. and 3 lbs. per cubic foot.

The idea of erecting pressure plants in India has been considered by at least one Railway Company and by several firms. Several of these schemes will no doubt eventually mature, the reason why they have not done so already is due to the difficulty of procuring the necessary plant in war time and to the fact that creosote has to be procured from Europe.

The question of producing creosote from Indian coal-tar has been the subject of an enquiry by a Calcutta firm, who have submitted samples to the Forest Research Institute for valuation and opinion. One sample sent by them very closely fulfilled all necessary conditions and a further sample is now under examination. In the event of it being found possible to obtain a suitable oil in India, an enormous impetus will at once be given to the antiseptic treatment of Indian Timbers.

Destructive Distillation of Wood.—The question of producing "Stockholm tar" from "Chir" waste and twisted wood was opened by Mr. Perrée, Conservator of Forests, Kumaon Circle, United Provinces. A series of very

interesting experiments have been carried out in this connection by the Divisional Forest Officer, West Almora, Mr. Canning, and similar experiments have been carried out at the Forest Research Institute. So far the results are not satisfactory, though progress has been made. It is thought that in course of time and with more experience it will be possible to manufacture this product on commercial lines, as the wood undoubtedly contains considerable quantities of tar, very closely allied to the "Stockholm tar" of commerce, the demand for which is large in India.

Physical and Mechanical Properties of certain Timbers.

(i) *Natural seasoning.*—A detailed enquiry has been undertaken with the object of determining the best methods of seasoning timber, with special reference to the relative advantages of girdling, seasoning in the open and under shade, the effect of felling at different seasons of the year, of converting timber green, the effect of water seasoning and slow seasoning by the help of "Ligno," "Loracine," "Cowdung and Earth," etc. The experiments are being carried out with upwards to 30 species of timbers in Bengal, Bombay, Central Provinces, Bihar and Orissa, United Provinces and the Punjab. In Burma, Mr. Rodger is co-operating with the Forest Research Institute and is carrying out seasoning experiments with Burman timbers on the same lines as those now in progress in other provinces. The results are being based on comparison and by taking moisture tests. The final results are as yet not available, though from inspections and reports received everything tends to show that very hard timbers, which are liable to excessive splitting should be converted when in a green state and not be seasoned in the log.

(ii) An interesting set of experiments were carried out last February at Digboi, Assam, in a plant put at the writer's disposal by Messrs. the Assam Oil Co., to ascertain the merits or otherwise of steam and oil seasoning. These experiments were carried out in connection with the seasoning of sleepers before treatment. The first set of experiments were carried out in a closed cylinder on green *Dipterocarpus pilosus* M. G. sleepers, the timber being subjected to a period of steaming at a temperature of 120°C, at a pressure of 20 lbs. per square inch and then subjected to a vaccum of 20″ column of mercury for 1¼ hours. This resulted in the weight of the green timber being reduced from 63·6 lbs. to 57 lbs. per cubic foot, whereas air-dried timber of this species weighs about 43 lbs. per cubic foot. The attempt to season timber in this way was, therefore, only partially successful.

In the oil seasoning experiments the timber was immersed in a closed retort filled with creosote oil and heated for seven hours' the temperature of the oil being gradually raised to 110°C. The vapours given off were condensed in a condenser pipe and collected. At the end of the period of heating the timber was subjected to a pressure of 15 lbs. for 15 minutes in order to complete the impregnation. The amount of sap collected through the condenser amounted to 4¾ gallons, while 2 gallons of moisture were reprecipitated in the retort and afterwards collected. The number of M. G. sleepers put into the cylinder was four, representing 6 cubic feet of timber, which gave off 6¾ gallons of moisture or a little over 11 lbs. per cubic foot. The weight of the green wood was therefore reduced from 63 lbs. to 52 lbs. per cubic foot, not taking into consideration the oil absorbed. Of the two methods tried oil seasoning gives considerably better results than steam seasoning, while neither process reduces the timber to an air-dry state.

(iii) *Mechanical tests on timber.*—A considerable number of tests were carried out on various timbers during the year, both in regard to the power of the timber to withstand Transverse, Compression and Shearing strain, and also to withstand Spike-pull. The timbers tested were *Picea Morinda, Abies Pindrow, Cynometra polyandra, Terminalia myriocarpa, Dipterocarpus pilosus, Altingia excelsa, Dillenia indica, Mesua ferrea, Bischofia javanica* and *Planchonia andamanica.*

(iv) Mr. A. Rodger, Research Officer, Burma, submitted 80 species of Burma timbers to the Government School of Engineering, Insein, to be tested for their mechanical properties, after being thoroughly seasoned.

Finding new Markets and uses for Timber.—Bulletins dealing with the uses, outturn and prices of *Lagerstrœmia parviflora, Dalbergia latifolia* (Blackwood) and *Heritiera minor* (Sundri) were published during the year; a fourth dealing with *Ptrocarpus santalinus* (Red Sanders) has been submitted for publication, while a fifth dealing with *Acacia arabica* (Babul) is under preparation.

Gums, Resins and Oleo-resins.—This enquiry has been confined to work on *Boswellia serrata* gum oleo-resin. The enquiry has now reached an advanced stage. The experimental tapping areas were again visited in Nimar, in connection with the effect of tapping on the trees. The conclusions arrived at have been dealt with in a detailed report, the most important items of which show that only over mature and very old or quite small trees are killed by tapping and that the wounds on other trees heal up entirely within 3 or 4 years. The other side to the enquiry deals with the preparation of the gum, rosin and turpentine, a subject which has been dealt with by the Chemi-

cal Adviser. Samples of all these products were submitted to Indian firms, while others were sent to the Imperial Institute for valuation. The gum has been provisionally passed as suitable for sizing by an Indian firm, though the sample sent home to the Imperial Institute was unfavourably reported on owing to the high percentage of rosin still remaining in the gum. The rosin has been well reported on for varnish work and as a suitable adulterant in the preparation of Shellac by Indian firms, and classed as "G" grade colophony by the Imperial Institute, while the turpentine is of a high grade and suitable for paint work. All Indian firms to whom samples have been sent have asked for larger samples with which to experiment on a commercial scale, these could not be supplied, as the Forest Research Institute laboratories contain no plant suitable in which to manufacture large samples, a condition of affairs much to be regretted, when considering the promising nature of this enquiry.

Mr. A. Rodger collected complete information as to the distribution of *Melanorrhœa usitata*, the "Thitsi" Damar tree of Burma, together with data on outturn, prices, uses and possibilities of this valuable oleo-resin, with a view of compiling a note on the subject.

Fibres.—A consignment consisting of 63 maunds of *Helicteres Isora* fibre was prepared by Rao Bahadur Shrinivasalu Naidu, Divisional Forest Officer, Nagpur-Wardha Division, and sent to a Calcutta Rope Factory to be tested for its value in rope making. The fibre was well prepared and proved suitable for making up into certain classes of rope. The success of such an experiment will depend on the price offered for this fibre as compared with the cost of collection, preparation and delivery, a point which cannot be settled until the final report on this consignment is received.

Information was collected by the Forest Research Officer, Burma, on the Chin Hill nettle fibre, with a view of ascertaining whether it could be collected on a commercial basis. The enquiry is in progress.

Essential Oils.—Flower heads of *Strobilanthes sp.* have been sent by the Forest Research Officer, Burma, to Calcutta with a view of ascertaining whether the yield and value of the oil is sufficient to justify collection. Were it possible to find a use for this plant it would materially assist Sylvicultural operations in the forests in which it constitutes a danger to natural regeneration.

Woods used for.—(i) *Paving blocks.*—Approximately 20,000 Sāl paving blocks were supplied to the Calcutta Corporation with which to experiment. These blocks were laid down in 1914-15, together with creosoted *Douglas Fir* and "Krabark" paving blocks. A recent report from the Chief Engineer of the Corporation states that all these blocks have given considerable trouble in the monsoon due to expansion and consequently a tendency for the pavement to buckle, necessitating continual attention to the expansion joints. This difficulty may result in the abandonment of the idea of using paving blocks, in so variable a climate as Calcutta. A similar experiment is in pro-

gress in Bombay, 9,260 creosoted Xylia *dolabriformis* and 18,814 untreated teak blocks having been supplied to the Bombay Municipality. These blocks were laid down with great care at the end of 1915. To date no report has been received as to their behaviour.

(ii) *Lead Pencils.*—A species of *Manglietia* timber was sent from Assam to be tested for pencil making but proved of little value owing to the difficulty experienced in finishing and polishing the wood. The only Indian timber which has so far proved at all suitable is *Juniperus macropoda*, of which the supply is very limited. Recently samples of Pencil Cedar, together with quotations, were received from the Equator Saw Mills, British East Africa, which demonstrated the fact that suitable timber can be imported into India within what may be found to be a working figure of cost.

(iii) *Jute Bobbins.*—The demand for jute bobbins is very great and a promising industry can without doubt be developed in India. Much attention has recently been paid to this subject both in connection with jute and cotton bobbins. In this connection samples of 32 species of timber have been submitted to a Calcutta firm for testing, on which the final report is now awaited.

(iv) *Other purposes.*—Many other enquiries were received during the year, for timbers suitable for such purposes as picking arms, rifle stocks, wood-wool, cog wheels, artificial limbs, lance shafts, shell plugs, etc., all of which were attended to, either by submitting samples of timber to be tested or by indicating the value of certain timbers which had already been tried and found suitable for the purpose under reference.

Manufacture of Cutch.—The Forest Research Officer, Burma, after recording measurements at centres of "Cutch" manufacture, was able to calculate the yield of cutch obtained by local manufactures per cubic foot of heart-wood from various sizes of trees. The final results of his investigations will, it is hoped, be available in due course.

Economic and Wood Museums.—Considerable additions have been made to both the Economic and Wood collections, while a catalogue for the former has been prepared and is now in the press.

List of Publications on Forest Economic Matters published during 1915-16.

ANGLE, H. M. . . Process of Wood Distillation. (*Journ. Soc. Chem. Industry, xxxv, 462.*)

BENSKIN, E. . . Note on Blackwood, *Dalbergia latifolia* (*For. Bull. No. 27 of 1915.*)

" " . Note on Dhauri, *Lagerstrœmia parviflora* (*For. Bull. No. 28 of 1915.*)

BOYER, J. . . . KAPOK—A New Textile Fibre, its Manufacture and Industrial application. (*Scientific American, Supplement, lxxxi, 121.*)

GOSS, O. P. M. . . Creosoted Wood Block Pavement. (*American Forestry, Vol. 22, 105-106.*)

MUMURA, SHOZABURO . Charcoal Burning in Japan (*Dept. Agri. and Commerce, Tokyo, Bul. For. Experi. Station, Megure, Tokyo.*)

PEARSON, R. S. . . Note on Sundri Timber, *Heritiera minor* (*For. Bul. No. 29 of 1915.*)

" " & Pr. PURAN SINGH. Note on the Economic Uses of Rosha Grass and on the Constants of Geranium oil (Motia) respectively. (*Ind. For. Rec. v, Part VII of 1916.*)

PHILIPS, C. . . India as a Source of Paper-Making Material. (*Trop. Agricult., xlv, 272-76.*)

RECORD, S. J. . . The Pine Needle Oil Industry. (*Scientific American, cxlv, 100.*)

SINGH, PURAN . . Note on the Indian Sumach, *Rhus Cotinus* (*For. Bul. No. 31 of 1916.*)

" " . . . The Camphor Content of *Cinnamomum Camphora* (*Ind. For., xli, 291-294.*)

" " . . . Note on the effect of age on the Catechin content of the wood of *Acacia Catechu* (*Ind. For., xli, 482-85.*)

SMYTHIES, E. A. . Some Financial Aspects of Resin Tapping in Chir Pine Forests. (*Ind. For., xlii, 187-201.*)

SRIVASTVA, J. P. . Dyeing Values of Some Indigenous Dye-stuffs. (*Ind. For., xlii, 325-334.*)

UNWIN, R. . . . Dry Distillation in Burma. (*Ind. For., xlii, 90-91.*)

WEISS, H. F. . . The Preservation of Structural Timber. (*U. S. Dept. of Agri., For. Ser. Bull. of 1915.*)

ZOOLOGY.

I—GENERAL ZOOLOGY AND PHYSICAL ANTHROPOLOGY

BY

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The most important event of the year so far as zoology is concerned has been the inauguration of a new Imperial Department with the title " Zoological Survey of India." This department is, so far as the staff, accommodation, etc., are concerned, merely the old Zoological and Anthropological Section of the Indian Museum under a new name. The fact, however, that it is now directly under the Government of India is of great practical importance for two reasons :—firstly, that it places expert advice on general zoology at the disposal of the Government, and secondly, that it will, when financial conditions become less stringent, permit of expansion in various directions.

As, however, the Survey was inaugurated only on the 1st July, 1916, and this report has to be prepared before the end of August, I think that it will be better to defer all further reference to the new department until next year and to submit now merely an account of the work done in the Indian Museum before July. In view of Government orders in reference to the scarcity of paper I have condensed this report considerably.

A.—Anthropological Collections of the Indian Museum.

The additions to the anthropological collection have been as usual few, but the gift by Dr. B. L. Choudhuri of a set of weighing-beams and solid-measures from Orissa is of considerable value. Mention may also be made of the fine sacrificial knife presented by Kumar Satya Mohan Ghosaul of Bhookoylas, Calcutta, in whose family it had been preserved for several generations.

Additions have also been made to the collection of anthropological photographs of the people of Calcutta.

B.—Zoological Collections of the Indian Museum.

Progress has been made in the arrangement of the collections of the section and in particular that of the named Lamellibranch shells, which has been completed.

The collections of insects, reptiles, etc., from the Darjeeling district presented from time to time by H. E. Lord Carmichael have been of great value, not only because they have included specimens of many rare and several previously unknown species, but also because they have enabled us to lay a good foundation for a scheme that we have been considering for some years, *viz.*, the preservation of two parallel sets of insects, one set pinned and the other in alcohol.

While on study leave in the Far East, I obtained large collections illustrating the lake-fauna of certain parts of Japan, China and the Malay Peninsula. These have been presented to the Museum. Together with collections from India and Palestine already in our possession they will give the Indian Museum an unique position as regards the invertebrate freshwater fauna of Asia, more especially in respect to neglected groups such as the sponges and polyzoa.

Important collections of a general nature have been presented by Mr. T. Southwell, Deputy Director, Fisheries, Bengal, Bihar and Orissa (from Eastern Bengal and Bihar); by Mr. J. Coggin Brown of the Geological Survey of India (from the North Shan States); by Mr. T. Bainbridge Fletcher, Imperial Entomologist (from different parts of Burma); by Captain R. B. S. Sewell, I.M.S., late Surgeon Naturalist (from Aden). Mr. W. Lancelot Travers has sent us a most interesting series of tortoises from the Jalpaiguri district of Bengal. These have cast much light on the distribution of the Chelonian fauna of Northern India. We are also indebted to Mr. M. C. Bonig of the Indian Forest Department for some interesting beetles and crustacea from the Andaman and spiders from the Nicobar Islands; to Colonel H. T. Pease, C.I.E., of the Civil Veterinary Department for insects and frogs from Kashmir; to Mrs. A. Drake for spiders from Bengal; to Mr. F. Hannyngton, I.C.S., for insects from Coorg and to Miss D. Molesworth for beetles from Upper Burma. Lieutenant-Colonel H. H. Godwin Austen has again sent us a number of interesting Indian land shells. Major J. Clayton Lane, I.M.S., has continued to present co-types of the Nematode worms he has described.

As comparatively little touring in India was possible owing to the absence of a member of the scientific staff for half the year, the collections made by our own officers in this country have been less important than usual. No zoological specimens of any importance have been purchased.

ENTOMOLOGICAL SECTION.

Scorpionidea.—Two scorpions from Cochin are still with Dr. J. R. Henderson.

Araneæ.—The spiders of the Abor Expedition are still with Dr. Nathan Banks. Professor R. Narayan has identified most of our ant-mimicking Attidæ and has published a paper on them in the "Records."

Acari.—Dr. Nathan Banks still has the Acari of the Abor Expedition other than ticks. Professor J. Nuttall and Mr. C. Warburton are still working on ticks for us. Mr. Hirst is still working on our mites from fowls.

Myriapoda.

Dr. Silvestri reports that he has finished his work on our Oniscomorpha and is now taking up the other groups of which material has been sent to him. Our symphyla are still with Mr. Bagnall.

Insecta.

Thysanura.—Still in the hands of Dr. Silvestri.

Collembola.—Dr. G. H. Carpenter still has the Collembola of the Abor Expedition.

Orthoptera.—Mr. H. S. Leigh, Dr. E. Giglio-Tos and Dr. J. L. Hancock still retain the material that is with them. Professor L. Chopard has revised our Cavernicolous Stenopelmatids. The cockroaches of the Abor Expedition have been sent to Dr. R. Hanitsch.

Odonata.—Mr. F. F. Laidlaw's work on our dragon-flies continues and has already resulted in the publication of several papers in our "Records."

Neuroptera (sensu lato).—Professor J. G. Needham has not yet returned the specimens that were sent him six or seven years ago.

Trichoptera.—Nothing more has been received from Dr. Betten.

Hymenoptera.—Dr. W. M. Wheeler's work on our ants, Dr. S. A. Rohwer's work on our saw-flies, and Dr. G. Grandi's work on our fig-insects still continues.

Coleoptera.—The work of Mr. G. J. Arrow, Mr. S. Maulik, Mons. Al Grouvelle, Mr. C. J. Gahan and Mr. G. A. K. Marshall on our collection still continues. Mons. P. de Peyerimhoff has described the larvæ of some Nitidulidæ and has sent us a paper on them which is being published in our "Records."

My work on our Lucanidæ has been completed and published and the working out of the Van der Poll Passalidæ purchased last year is now in hand. Dr. A. Griffini has gone to the war and has consequently been unable, to work out our Bolboceridæ as he had intended. The material has not yet come back to us.

Diptera.—The work of Mr. E. Brunetti and Prof. M. Bezzi still continues. Our Muscidæ have been sent for determination to Dr. C. H. Townsend.

Thysanoptera.—Still with Mr. S. Bagnall.

Aphaniptera.—The Hon'ble Chas. Rothschild still names fleas for us as occasion requires.

Hemiptera.—The work of Mr. W. L. Distant and Mr. E. A. Andrews continues, the former having recently sent back some of the material sent to him. Dr. P. Van der Goot has finished working out our Aphids and has named and returned the material. Mr. E. E. Green still has some coccids belonging to our collection.

FIELD WORK OF THE MUSEUM STAFF.

Most of the field-work attempted during the year has consisted of short trips to various parts of Orissa, with the object of obtaining specimens of marine and lacustrine animals for comparison with those obtained in our survey of the Chilka Lake.

Dr. F. H. Gravely spent three weeks at Pashoke in the Darjeeling district and made a large collection of insects and other animals.

H. E. Lord Carmichael was good enough to permit Mr. R. A. Hodgart, Museum Collector, to accompany him on a visit to the interior of the Chittagong district of Bengal. Although the time was very short, a number of interesting specimens were obtained in a district which has been very little explored.

RESEARCH.

The researches, both zoological and anthropological noted in last year's report, are being continued. The results achieved are recorded in the publications of the Museum.

List of Publications on Indian Zoology.

The following list of books, memoirs, etc., that have a direct bearing on Indian Zoology and were published between the months of September 1915 and August 1916 has been drawn up as usual by Dr. B. L. Chaudhuri.

Of the work done in the Indian Museum the most important is perhaps that on the fauna of the Chilka Lake noted under the headings Crustacea, Insecta, Mollusca, etc. Attention may also be directed to Dr. James Ritchie's account of the very peculiar Hydroid *Annulella gemmata* from brackish water, published in the "Records of the Indian Museum" but worked out in Edinburgh.

The Bombay Natural History Society, in spite of difficulties due to the war, has continued its survey of the Indian mammals.

Mr. James Hornell of the Madras Fishery Department is about to publish an interesting account of the races of the common chank shell in the Memoirs of the Indan Museum. An extract has already appeared.

Mr. W. L. Distant has published a sixth volume on the Rhyncota in the "Fauna of the British India."

GENERAL.

GAIGER, S. H. . . A revised check list of the animal parasites of domesticated animals in India. (*Jour. Comp. Path. Therap., xxviii, 67.*)

PORIFERA.

ANNANDALE, N. . . Some sponges parasitic on Clionidæ with further notes on that family. (*Rec. Ind. Mus., xi, 457.*)

CŒLENTERATA.

LLOYD, R. E. & ANNANDALE, N. On the hydrozoon *Campanulina ceylonensis* (Browne). (*Rec. Ind. Mus., xii, 49.*)

RITCHIE, JAS. . . The Hydroids of the Indian Museum, II—*Annulella gemmata*, a new and remarkable Brackish-water Hydroid. (*Rec. Ind. Mus., xi, 541.*)

ECHINODERMATA.

CLARK, H. L. . . The Echinoderms of Ceylon other than Holothurians. (*Spol. Zeyl. x, 83.*)

PEARSON, J. . . Note on *Halodeima atra* (*Holothuria atra*). (*Spol. Zeyl., x, 175.*)

HELMINTHS.

LANE, C. . . . The correct names of the Helminths of man. (*Ind. Med. Gazet., 41, 165.*)

STEWART, F. H. . *Hymenolepsis nana* (Siebold), the Dwarf Tapeworm, as a parasite of Indian soldiers. (*Ind. Med. Gazet., li, 218.*)

SOUTHWELL, T. . . On some Indian Cestoda. (*Pt. ii.*) (*Rec. Ind. Mus., xii, 5.*)

ANNELIDA.

STEPHENSON, J.. . On some Indian Oligochæta mainly from Southern India and Ceylon. (*Mem. Ind. Mus., vi, 35.*)

The Geographical Distribution of Indian Earthworms. (*Proc. Asiat. Soc., Bengal, xii, cxvii.*)

CRUSTACEA.

COLLINGE, W. E. . Contributions to a knowledge of the Terrestrial Isopoda of India. Pt. II. Some new species of *Paraperiscyphis*, *Cubaris*, etc. (*Rec. Ind. Mus., xii, 115.*)

Terrestrial Isopoda, II (*Abor Expedition, 1911-12*) (*Ibid, viii, 543*).

KEMP, S. . . . Stomatopoda. (Fauna of the Chilka Lake, No. 2.) (*Mem. Ind. Mus., v, 191.*)

Crustacea Decapoda (Fauna of the Chilka Lake, No. 3). (*Mem. Ind. Mus., v, 199.*)

Cumacea (Fauna of the Chilka Lake, No. 4). (*Mem. Ind. Mus., v, 393.*)

Indian Freshwater Prawns of the family Atyidæ. (*Proc. Asiat. Soc., Bengal, xii, cxvii.*)

TATTERSALL, W. M. . Mysidacea of the Lake, with the description of a species from the coast of Orissa. (Fauna of the Chilka Lake.) (*Mem. Ind. Mus., v, 147.*)

MYRIOPODA.

SILVESTRI, F. . . Four new species of the *Aulacobolus* Poc. (Diplopoda : Spirobolidæ) from India. (*Rec. Ind. Mus., xii, 41.*)

Contibuzione alla Conoscenza degli Stemmiuloidea (Diplopoda). (*Boll. Lab. Zool. Agri. Portici., x, 287.*)

ARACHNOIDEA.

GRAVELY, F. H. . Notes on Pedipalpi in the collection of the Indian Museum, V.—Tartarides collected by Mr. B. H. Buxton in Ceylon and the Malay Peninsula. (*Rec. Ind. Mus., xi, 383.*)

A revision of the Oriental sub-families of Tarantulidæ (Order Pedipalpi). (*Ibid, xi, 433.*)

Notes on the habits of Indian Insects, Myriopods and Arachnids. (*Ibid, xi, 483.*)

The Evolution and Distribution of the Indo-Australian Thelyphonidæ, with notes on the distinctive characters of various species. (*Ibid, xii, 59.*)

HIRST, S. . . . On some new Acarine Parasites of rats. (*Bull. Entom. Research, vi, 183.*)

KUNHIKANNAM, K. . An aggresive mimic of the Red Tree Ant. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 373.*)

NARAYAN, K. . . Notes on Ant-like spiders of the family Attidæ in the collection of the Indian Museum. (*Rec. Ind. Mus., xi, 393.*)

OUDEMANS, A. C. . Notizen uber Acari XXI. Reihe (Parasitidæ.) (*Tijdsch. Entom. Nederl. Entom. Vereeh., 1915, 192.*)

INSECTA.

ANNANDALE, N. & KEMP, S. Aquatic insects other than Coleoptera, with notes on some marginal species. (Fauna of the Chilka Lake, No. 2.) *Mem. Ind. Mus., v, 175.*)

AYYAR, T. V. R. . . Occurrence of *Himantopterus caudatus*, Moone, on the Bababudine Hills. (*Jour. Bom. Nat. Hist. Soc., xxiv, 378.*)

BALLARD, S. . . The host plant of the scale *Inglisia cheloinoides*, green. (*Ibid*, 378.) An Erotylid Grub in Thenai at the Central Farm, Coimbatore. (*Agric. Journ. Ind., x, 302.*)

Calocoris angustatus, Leth. (*Agric. Research Instit., Pusa, Bull. No. 58.*)

BARROW, H. J. W. . Note on *Gerydus boisduvali* (Moone). (*Jour. Bom. Nat. Hist. Soc. xxiv, 372.*)

BEESON, C. F. C. . Ambrosia Beetles on pinhole and shot-hole Borners (*Col. Fam. Ipidæ, Platypodidæ*). (*Ind. For. xlii, 216.*)

BERGROTH, E. . . Hemiptera from the Bombay Presidency. (*Journ. Bomb. Nat. Hist. Soc., xxiv, 170.*)

BOUCAMONT, A. . . Onthophages asiatiques nouveaux ou peu connus. (Ann. Mus. Civic. Stor. Nat. Genova, *vi* (*Series 3a.*), *210.*)

CARL, J. . . . Acridides nouveaux ou peu connus du Museum de Genève. (*Rev. Suis. Zool. Ann., xxiv, 461.*)

CHAMPION, G. C. . . The Xylophilidæ of Ceylon. (*Ann. Mag. Nat. Hist., xvi* (*Suser*), *215.*)

CHATTERJEA, N. C. . Chemotropism, influence of Kusum oil on insects. (*Journ. Bom. Nat. Hist. Soc., xxiv, 198.*)

CHRITOPHERS, S. R. . The Pilotaxy of *Anopheles*. (*Ind. Journ. Med. Research, iii, 362.*)

The Male Genitalia of *Anopheles*. (*Ibid, iii, 371.*)

CREAWFORD, D. L. . Ceylonese and Phillipine Psyllidæ (Homoptera). (*Philipp. Journ. Sci. Vol. x, Sec. D., No. 4, p. 257.*)

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* The full paper is still in the press. Only the preliminary note published in the Journal of the Asiatic Society of Bengal is included in the list.

DE PEYERIMHOFF, P. . Description de la Larvæ de *Lasiodatylus cherolati*, Reitt. (*Rec. Ind. Mus. No. 6, 1916, 125.*)

DISTANT, W. L. . . Rhynchota. (Homoptera: Appendix.) (*Fauna of British India.*)

EDWARDS, F. W. . Eight new mosquitos in the British Museum Collection. (*Bull. Entom. Research, Lond., vi, 357.*)

FLETCHER, T. B. . One hundred Notes on Indian Insects. (*Bull. 59, Agri. Research. Inst., Pusa.*)

GOOT, P. VANDER . On some undescribed Aphides from the collection of the Indian Museum. (*Rec. Ind. Mus., xii,* i.)

GRAVELY, F. H. . . The Larvæ and Pupæ of some Beetles from Cochin. (*Rec. Ind. Mus., xi, 353.*)

Coleoptera, IX: Tenebrionidæ (*Zoological Results of the Abor Expedition, 1911-12*). (*Rec. Ind. Mus., viii, 519.*)

A Catalogue of the Lucanidæ in the collection of the Indian Museum. (*Rec. Ind. Mus., xi, 407.*)

Notes on the habit of Indian Insects, Myriopods and Arachnids. (*Ibid, xi, 483.*)

GREEN, E. E. . . Observations on some recently described Coccidæ. (*Bull. Entom. Research, vii, 51.*)

GROUVELLE, A. . . Descriptions d'espèces nouvelles de Cryptophagidæ (Etudes sur les Coleopteres). (*Mem. Soc. Entom.*) *France, i, 1916, 30*).

HENRY, G. M. . . Note on two observations of Ceylon Butterflies. (*Spol. Zeylz., x, 117.*)

Cannibalism in *Pulchriphyllium crurifolium*, Serv. (*Ibid, x, 176.*)

HOWLETT, F. M. . . A preliminary note on the identification of Sand-flies. (*Bull. Entom. Research, vi, 293.*)

Chemical reactions of Fruit-flies. (*Bull. Entom. Research, vi, 297.*)

IMMS, A. D. & CHATTERJEE, N. C. On the structure and Biology of *Tachardia lacca*, Kerr, with observations on certain insects predaceous or parasitic upon it. (*Ind. For. Mem. iii, p. I.*)

JACKSON, A. C. . . Living male specimens of the Indian Stick Insects. (*Proc. Zool. Soc., 1915, 155.*)

LUDLOW, C. S. . . The Synonyms of *Anopheles christophersi*, Theo., and *A. indefinite*, Ludl. (*Bull. Entom. Research, vi, 155.*)

LAIDLAW, F. F. . .	Notes on Oriental Dragonflies in the Indian Museum No. 3. (*Rec. Ind. Mus., xi, 387.*)
	Notes on Oriental Dragonflies in the Indian Museum, No. 4. (*Ibid, xii,* 21.)
	Odonata (Fauna of the Chilka Lake, *No. 2*). (*Mem. Ind. Mus., v, 178.*)
MARSHALL, C. A. K. .	Some Injurious Indian Weevil (Curculionidæ). (*Bull. Entom. Research, v, 377.*)
MAULIK, S. . .	Cryptostomes of the Indian Museum, Pt. II. (*Rec. Ind. Mus., xi, 367.*)
	A new *Chlamys* from Calcutta. (*Ibid, xii, 101.*)
MORLEY, C. AND TURNER, R. E.	Notes and Synonymy of Hymenoptara in the collection of the British Museum. (*Ann. Mag. Nat. Hist., xvi (8th series), 331.*)
MUIR, G. B. F. . .	Sense of locality in a leaf-cutting Bee. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 374.*)
MITTER, J. L. . .	The Occurrence of *Stygeromyia maculosa* at Kasauli and its breeding place. (*Ind. Journ Research, 395.*)
PIC, M. . . .	Nouveaux Zonabris de l'Inde et de Cochinchine. (*Bull. Soc. Entom. France, No. 6, 1916, 125.*)
	Nouveau Cerambycide d'Asie (Col.) (*Ibid, No. 7, 1916, 141.*)
PROUT, L. B. . .	New genera and species of Indo-Australian Geometridæ. (*Novit. Zoolog., xxiii, 1.*)
RITSEMA, C. . .	Description of five new Asiatic species of the Coleopterous genus *Helota*. (*Tijdsch. Entom. Nederl. Entom. Vereen, 1915, 244.*)
RUTHERFORD, A. .	Some new Ceylon Coccidæ. (*Journ. Bomb. Nat. Hist. Soc., xxiv, III.*)
	Notes on Ceylon Coccidæ. (*Spol. Zeyl., 103.*)
SWINHOE, C. . .	New Species of Indo-Malayan Lepidoptera. (*Ann. Mag. Nat. Hist., xvi, (8th Series), 170.*)
TYTLER, H. C. . .	Notes on some new and interesting Butterflies from Manipur and the Naga Hills. Parts III & IV. (*Journ. Bomb. Nat. Hist. Soc., xxiv, 119.*)
WATERSTON, J. . .	New species of Chalcidoidea from Ceylon. (*Bull. Entom. Research, v, 325.*)
WATSON, J. H. . .	A new race of *Attacus atlas*. (*Tijdsch. Entom. Nederl. Entom. Vereen 1915, 278.*)

MOLLUSCA.

ANNANDALE, N. & KEMP, S. Mollusca Gastropoda and Lamellibranchiata. (Fauna of the Chilka Lake). (*Mem. Ind. Mus., v, 327*).

ELIOT, C. . . . Mollusca Nudibranchiata. (*Fauna of the Chilka Lake.*) (*Mem. Ind. Mus., v, 375.*)

GHOSH, E. . . . An account of the Anatomy of the common Solen. (*Fauna of the Chilka Lake.*) (*Mem. Ind. Mus., v, 367.*)

GODWIN-AUSTEN, H. H. Mollusca, VI (*Abor Expedition*). (*Rec. Ind. Mus., viii, 547.*)

HORNELL, J. . . The Indian varieties and races of *Turbinella pyrum* (Linn.). (*Journ. Proc. Asiat. Soc., Bengal, N. S., xii, cxv.*)

PRESTON, H. B. . . Mollusca, V. (Zoological Results of the Abor Expedition.) (*Rec. Ind. Mus., viii, 537.*)

Report on a collection of Mollusca from the outskirts of Calcutta. (*Ibid., xi, 479.*)

Report on a collection of Mollusca from the Cochin and Ennur backwaters. (*Ibid, xii, 27.*)

Report on a small collection of Marine Mollusca dredged in shallow water in the Andaman Islands. (*Ibid, xii, 87.*)

SOWERBY, G. B. . . . Descriptions of new species of Mollusca from various localities. (*Ann. Mag. Nat. Hist., xvi (8th ser.), 164.*)

BRACHIOPODA.

ASHWORTH, J. H. . On larvæ of *Lingula* and *Pelagodiscus* (*Discinisca*). (*Trans. Roy. Soc., Edin., li, 45.*)

TUNICATA.

OKA, A. . . . Report upon the Tunicata in the collection of the Indian Museum. (*Mem. Ind. Mus., vi, 1.*)

FISH.

BHATTACHARYA, D. R. Stages in the life history of *Gobius*, *Petrosurtes* and *Hemirhamphus*. (Fauna of the Chilka Lake.) (*Mem. Ind. Mus., v, 381.*)

CHAUDHURI, B. L. Descriptions of two new fish from the Chilka Lake, (*Rec. Ind. Mus., xii, 105.*)

Fish, Pt. I. (Fauna of the Chilka Lake.) (*Mem. Ind. Mus., v, 403.*)

HOWELL, G. C. L. . Notes on the Respiration of the "Murral" (Ophiocephalidæ). (*Journ. Bomb. Nat. Hist. Soc., xxiv, 195.*)

The making of a Himalayan Trout water. (*Ibid, xxiv, 317.*)

WHITEHOUSE, R. H. . Notes on Elasmobranch Blood cells. (*Proc. Asiat. Soc. Bengal, N. S., xii, cxv.*)

BATRACHIA.

ANNANDALE, N. . . Mammals, Reptiles and Batrachians (Fauna of the Chilka Lake, *No. 2*). (*Mem. Ind. Mus., v, 163.*)

FISCHER, C. E. C. . The habits of *Rana semipalmata*, Boul. (*Journ. Bomb. Nat. Hist. Soc., xxiv, 194.*)

WOODLANDS, W. N. F. Notes on some recent enquiries concerning the so-called "Renal-Portal" system in Vertebrates. (*Jour. & Proc. Asiat. Soc. Bengal, N. S., xii, cxiii.*)

REPTILES.

ANNANDALE, N. . . Mammals, Reptiles and Batrachians. (Fauna of the Chilka Lake, *No. 2.*) (*Mem. Ind. Mus., v, 163.*)

FISCHER, C. E. C. . *Dryophis dispar* (Gunth). (*Journ. Bomb. Nat. Hist. Soc., xxiv, 194.*)

BIRDS.

BAILEY, F. M. . . Birds. (*Notes from Southern Tibet.*) (*Journ. Bomb. Nat. Hist. Soc., xxiv, 74.*)

BAKER, E. C. S. . . The Game Birds of India, Burma and Ceylon, Part XVII. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 1, 201.*)

BEADON, C. . . Nest of Common sand-grouse. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 192.*)

DEWAR, D. . . A Bird Calendar for Northern India. (London (Thacker).)

HARTERT, E. . . Notes on Pigeons. (*Novit. Zoolog. xxiii, 78.*)

HODDING, G. H. . . Fantail snipe (*Gallinago coelestes*) breeding on the Teesta river. (*Jour. Bomb. Nat. Hist. Soc. xxiv, 367.*)

JONES, A. E. . . Distribution of *Emberioza leucocephala*, the Pine-Bunting. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 357.*)

Gyps tennirostris (*Hodgson*), *the Himalayan long-billed* Volture, breeding near Ambala, Punjab. (*Ibid, 358.*)

A further note on the breeding of the Hobby (*Falco subbuteo*) near Simla, N.-W. Himalayas. (*Ibid, 359.*)

A note on the nidification of the Green Shrike-Tit (*Pteruthius xanthochloris*). (*Jour. Bomb. Nat. Hist. Soc., xxiv, 369.*)

LUDLOW, F. Breeding of the Marbled Teal (*Marmarouetta angustirostris*) and other birds at Sonmeani, Baluchistan. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 368.*)

MACKINTOSH, L. J. . Birds of Darjeeling and India.

MITCHELL, P. C. . . Stomach and intestines of the Open Bill. (*Proc. Zoolog. Soc., 1915, 153.*)

OSMASTON, B. B. . Curious Habits of Wood-peckers in the Kumaon Hills. (*Jour. Bomb. Nat. Hist. Soc. xxiv, 393.*)

RADCLIFFE, H. D. . List of the Birds of Baluchistan. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 156.*)

TICEHURST, C. B. . Note on a Wagtail new to the Indian List. (*Bull. Brit. Orn. Club, xxxv, 1.*)

WHISTLER, H. . . Notes on the Birds of the Jhelum District of the Punjab. (*Ibias. 10th Ser., iv, 35.*)

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ALLAN, C. W. . . A tree-climbing Tiger. (*Ind. For., xlii, 237.*)

ANNANDALE, N. . . Mammals, Reptiles and Batrachians. (Fauna of the Chilka Lake, *No. 2.*) (*Mem. Ind. Mus. v, 163.*)

BAILEY, F. M. . . Mammals. (Notes from Southern Tibet.) (*Jour. Bomb. Nat. Hist. Soc., xxiv, 72.*)

INGLIS, C. M. . . The Painted Bat (*Kerivoula picta*, Pall) in Tirhout. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 354.*)

POCOCK, R. J. . . On some of the External Characters of the Genus Linsang with notes upon the genera *Poiana* and *Eupleres*. (*Ann. Mag. Nat. Hist., xvi* (*8th Ser.*). *341.*)

POCOCK, R. J. . . On the feet and glands and other external characters of the Viverrinæ, with descriptions of a new genus. (*Proc. Zool. Soc., 1915, 131.*)

" . . On some of the External Structural Characters of the Striped Hyæna (*Hyæna hyæna*) and related genera and species. (*Ann. Mag. Nat. Hist., xvii (8th Ser.), 330.*)

PRIMROSE, C. . . Notes on the habit of the Harlequin Bat (*Scotomanes ornatus*). (*Jour. Bomb. Nat. Hist. Soc., xxiv, 353.*)

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THOMAS, O. . . A special genus fo the Himalayan Bat known as *Murina grisea*. (*Ann. Mag. Nat. Hist., xvi (8th Ser.), 309.*)

" . . Further notes on Asiatic Bamboo-rats. (*Ibid, xvi (8th Ser.), 313.*)

" . . On Pipistrels of the genera *Pipistrellus* and *Scotozous*. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 29.*)

" . . A second species of *Cœmolys* from Ceylon. (*Ibid. Ditto, 49.*)

" . . On some specimens of *Vaudeleuria* from Bengal, Bihar and Orissa. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 54.*)

" . . Notes on *Taphozous* and *Saccolaimus*. (*Ibid., Ditto, 57.*)

" . . The Porcupine of Tenasserim and Southern Siam. (*Ann. Mag. Nat. Hist. xvii (8th Ser.), 136.*)

" . . A new Marmot from Chitral. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 341.*)

" . . The Races of *Dremomys pernyii*. (*Ann. Mag. Nat. Hist. (8th Ser.), xvii, 391.*)

" . . On the generic names applicable to the Chevrotains (Tragulidæ). (*Ann. Mag. Nat. Hist. (8th Ser.), xviii, 72.*)

THOMAS, O. & WROUGHTON, R. C. The Giant Squirrels of Ceylon. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 34.*)

" " . . The Singhalese species of *Funambulus*. (*Journ. Bomb. Nat. Hist. Soc., xxxiv, 321.*)

On the squirrels obtained by Messrs. Shortridge and Macmillan on the Chindwin River, Upper Burma. (*Journ. Bomb. Nat. Hist. Soc., xxiv, 224.*)

WROUGHTON, R. C. . The Ceylon Hare. (*Journ. Bomb. Nat. Hist. Soc., xxiv, 41.*)

" " . . The Indian ribbed-faced Deer or Muntjac. (*Ibid, 42.*)

" " . . The Genus *Epimys* in Ceylon. (*Ibid, Ditto, 46.*)

" " . . The Common Indian Mongoose. (*Ibid, Ditto, 50.*)

" " . . A new Monkey from Chindwin River. (*Ibid, Ditto, 55.*)

" " . . The Burmese Civets. (*Ibid, Ditto, 63.*)

" " . . Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. Report Nos. 18 and 19. (*Jour. Bomb. Nat. Hist. Soc., xxiv, 79.*)

" " . . Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. Report No. 20. (*Ibid, xxiv, 291.*)

" " . . Bombay Natural History Society's Mammal Survey of India Burma and Ceylon. Report No. 20. (*Ibid xxiv, 291.*) (*Chindwin River.*)

ZOOLOGY.

II.—ECONOMIC ZOOLOGY.

Part I—Agricultural Entomology.

BY

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I.—Work at Pusa.

Insect Pests.—The following list shows, under the heading of a few main crops, the more important investigations carried out during the year on various insect pests of crops. Other work is shown under other headings (Life-histories, etc.) but it is not possible, in a brief Report of this nature, to mention, even by name, all the insects dealt with during the year.

Cotton.—Experiments, commenced last year, were continued to test the relative immunity to Bollworm attack of different varieties of cotton from the United Provinces, the Punjab, Bombay, the Central Provinces, and Madras. With this object in view, two sowings of each variety were made, one planted thickly and the other thinly, and weekly counts of affected bolls have been made separately for each series. The parasites that emerged were counted, recorded, and liberated; their hibernation and alternative hosts were also studied. One unexpected discovery was that there are apparently at least five different species of *Rhogas* which attack Cotton Bollworms (*Earias fabia* and *E. insulana*); their discrimination may prove to be of practical importance in control of Bollworm by means of its parasites. The life-history of *Earias fabia* was worked out and repeated; it will be repeated again for the different seasons of the year. The seasonal colour variation of Bollworm moths was also studied and a long series of specimens retained showing range of variation. Studies were also made of the utility of trap crops in connection with control of Bollworm. The advantage of sowing cotton as a mixed crop was also studied and these experiments will be continued and the results written up as requisite.

At the end of May 1915 the Director of Agriculture, Punjab, requested the despatch to Hansi of Bollworm parasites in order to establish a breeding plot and so facilitate their distribution in the Punjab. Between 7th June and 22nd July 1915, 158 grubs and pupæ of *Rhogas* spp. were despatched from Pusa to Hansi, and after the latter date sendings were discontinued as the parasites were fully established in the experimental plots at Hansi.

Rice.—A diseased condition of growing Rice-plants, by which the whole growing stem is converted into a long, white, hollow gall, has long been supposed to be due to attack by a Cecidomyiad fly, but little was really known about it, although a loss of thirty *per cent.* or more of the crop sometimes occurs. An outbreak of this disease being reported from Ranchi in September 1915, opportunity was taken to study it and it was found that the gall-formation is caused by a small fly (*Pachydiplosis oryzæ*, Wood-Mason) whose life-history was worked out in some detail, but further observations and experiments are required before the recommendation of control measures on a field scale.

Jassid bugs, locally known as "Maho," under which name are included *Nephotettix bipunctatus*, *N. apicalis* and (in less numbers) other similar species, have become a serious pest of paddy in the Central Provinces during the past two years. To help in investigation and control of this outbreak one Fieldman was lent from Pusa for the period April-October 1915 and a second Fieldman in August-November. Mr. Misra, First Assistant, also visited the affected areas in October to investigate the pest, note the damage done, and assist in control work.

Considerable attention has also been paid to these species of *Nephotettix* at Pusa, as regards their exact life-history, hibernation and alternative food-plants, but so far very little light has been thrown on these points. Numerous attempts to breed *Nephotettix bipunctatus* from the egg in captivity have been uniformly unsuccessful. Grass lands and areas which were under rice last season were frequently bagged and a powerful light-trap was also placed in these areas but, from the beginning of December 1915 up to 26th June 1916 not a single specimen of *Nephotettix* could be found, the first example being found amongst grass on 27th June 1916. There is therefore at present an interval of some seven months in the year, during which we know nothing of the life-history of this insect. Work is being continued.

Specimens of Fulgorid bugs, also found on rice in the Central Provinces proved to be *Sogata pusana*, *S. pallescens* and *S. distincta*, whilst Mealy-bugs on rice at Balasore have been identified by Mr. E. Ernest Green as *Ripersia sacchari niger*.

Sugarcane.—The work of rearing cane-borers was continued, fresh affected cane, maize, juar, millets, wild grasses, etc., being collected and the borers and their parasites reared out. Several broods of moths, bred from known parents themselves reared in both cane and juar, were also reared to ascertain the variability of certain characters. As material accumulates it seems to become increasingly evident that the cane-borers are two or more species of *Diatræa*, which may occasionally attack juar, maize, etc., and that the normal borer in these cereal crops is *Chilo simplex* which is rarely found in cane. Further collection and study are required of material from all parts of India as the question of identity is of importance as regards control.

From observations made at Tharsa Farm, in the Central Provinces, it seems that there is some possibility of reducing the incidence of borers (in this case principally *Schoenobius*) by varying the time of planting the cane. With this view a small experimental plot of half-an-acre under both thick and thin varieties of cane was planted at Pusa by the end of October 1915.

The sugarcane Aleyrodid (*Aleurolobus barodensis*) was reported from Tharsa as doing considerable damage to canes in the experimental plots. Measures for control were suggested and a large amount of material was also collected and reared to find out whether any effective parasite was present; but no parasite of any importance was obtained.

Papua depressella has hitherto been noted as boring principally in the roots of cane, being mostly in evidence in the ratoon crop. This year it exhibited a new habit by attacking new shoots of newly-planted cane in the early part of the hot weather (April-May), causing greater damage than either *Diatræa* or *Scirpophaga*. The external symptom of attack is "dead-heart" as in the case of boring by *Diatræa*, *Scirpophaga* and *Sesamia*.

A series of experiments was carried out on the protection of cane setts from attack of Termites, the following substance being tried, *viz.* :—Lead Arsenate, Resin Compound, Fish-Oil Soap with Resin, Crude Oil Emulsion, and Naphthaline Emulsion. Of these Lead Arsenate proved to be the best. In this connection it may be observed that it is not only the setts themselves which require protection but also the new shoots—in fact, in most cases the shoots are most attacked, being eaten into at the point of exit from the sett. It is of course much more difficult to protect these shoots than the setts and, to achieve this, additional treatment is usually necessary. Further experiments will be undertaken on this line next season.

Indigo.—During the year two Indigo Pests (Indigo Aphid and *Dichomeris ianthes*) were reported from two factories, Barh Chakia and Tateriah, both in North Bihar. A Fieldman was sent to spray the infested fields with Soap Solution. Two sprayings were given and the effect was reported to be good by the Managers of the factories concerned.

Coffee.—The year 1915 was marked by a very bad outbreak of Coffee Borer (*Xylotrechus quadripes*) in Coorg. One group of estates in South Coorg, of about 500 acres, removed approximately 100,000 bored bushes between 1st June and 31st October 1915. The Imperial Entomologist toured in Coorg in October and November to investigate this insect. The beetles began to emerge in the last week of October and were common by the first week of November. Eggs were obtained and hatched out and it was proved that sunshine is not essential to the hatching of the eggs, as stated by former observers. The eggs, which are white, soft, of rather indeterminate shape rather like minute rice-grains, are thrust singly or in little groups (of about 6-8) inside cracks and under scales of bark of coffee bushes; they are rarely visible, and very rarely laid externally. Experiments were started to ascertain the length of life-cycle, as it has been uncertain

whether there are one or two broods in the year. Results will be written up when further information on these experiments comes to hand.

Information was also collected on pests of *Erythrina lithosperma*, which is extensively grown for shade and green-manure on Coffee Estates.

Orchard and Garden Pests.—A special study has been made during the last three years of Insect Pests of cultivated Fruits, Vegetables and Flowers and a considerable amount of information has been collected on the insects concerned, their identity, life-history, food-plants, occurrence and control. This information will, it is hoped, be issued shortly as a Bulletin.

Special attention has also been paid to the collection of Fruitflies. A large collection of these was sent to Professor Mario Bezzi, of Turin, last year but was apparently lost in the S.S. "Persia" on return after identification; fortunately, the types of eight new species had been sent direct to the British Museum by Professor Bezzi. *Myiopardalis pardalina*, the "Baluchistan Melon Fly," was reared at Pusa from fruits of *Cucumis trigonus*; it was not hitherto known to occur except in North-Western India.

An important find during the year was the European Olive Fly (*Dacus oleæ*) in wild olives in the North-Western Frontier Province. Its occurrence in India was hitherto unknown and it is likely to be of importance in view of the attempts now being made to introduce the cultivation of the European Olive in North-West India and Kashmir.

Life-Histories of Insects.—In the Insectary were reared about 200 species of insects which had not been reared before. These included about fifty Coleoptera, of various families, of which there was no previous information regarding their breeding-places and habits. Many interesting facts have been noted in this connection; for example, one Elaterid beetle grub (*Agrypnus* sp.) has now been living in the Insectary for twenty-one months, its food consisting of Scarabæid and other beetle grubs with similar habits of working under the surface of the soil, most of them damaging roots of plants.

As mentioned in last year's Report, *Bruchus affinis* was observed to lay eggs extensively on pea-pods at Pusa in January and February, so that the peas may be infected in the field before being stored. The habits of this beetle have since been investigated more thoroughly. The grubs are brought into the store inside the seeds which are externally quite sound at harvest-time, about the end of January. The beetles begin to emerge from the seeds in August, but they do not become active until about December or January, the majority of the beetles remaining inside the seeds and thus having a chance of being taken back to the field at sowing-time. Seeds from pods on which eggs were laid suffered to the extent of about 50 *per cent.* of the crop, whilst the remainder of this same crop (after separation of these pods with visible eggs) suffered a damage of only 3-5 *per cent.*, and this was probably due to a small percentage of eggs being passed over. Treatment with Carbon Bisulphide or Naphthaline successfully prevented damage to the peas in store. A simple treatment (immersion of the seeds in water, when those attacked float

and the unattacked seeds sink) has been found efficient for separation of the affected from the unaffected seeds and therefore it is possible to avoid liberation of the beetles in the field at the sowing time.

Bruchus chinensis breeds throughout the year in Pulse seeds in store. This insect has been observed to breed in Gram, Mung (*Phaseolus mungo*), Urid (*P. radiatus*), Bakla (*P. aconitifolius*), Kulthi (*Dolichos biflorus*), Lentil, Khesari (*Lathyrus sativus*) Arhar (*Cajanus indicus*), Bora (*Vigna catjang*), and large and medium peas. A small variety of local indigenous pea has been found to be immune from its attack. Eggs are laid on this variety as on others, but the grubs cannot bore or feed in this pea, which is, however, more liable to attack by *Bruchus affinis* in the field.

The work of breeding *Agrotis ypsilon*, referred to in last year's Report, was continued in order to find out how it passes through the Hot Weather and Rains (April-September). In the Insectary it continued to breed throughout this period. The moths, however, which emerged in July-August did not lay fertile eggs although they had full chances of mating; possibly this was due to inbreeding under unfavourable conditions; at any rate, fertile eggs were not obtained. But, as it was, the insect bred in captivity until about the time (August) when the moths normally appear in the *tal* lands which are subject to attack at Mokameh. During 1916 an Andres-Maire trap was worked in the Insectary compound at Pusa throughout the Hot Weather (April-June) to see whether any moths of *Agrotis ypsilon* could be attracted but not a single example was captured. What actually happens under normal conditions remains, therefore, still a mystery. The insect can continue to breed under favourable conditions but we have no evidence that it actually does so. Our Insectary experience has yielded no indication of any inclination to pass through the Hot Weather in any resting stage; on the contrary, breeding was continuous until August. On the other hand no trace of the insect has been found under natural conditions between April and August. The migration theory fits the known facts but as yet remains an unproved hypothesis.

Colonies of *Odontotermes assmuthi*, established in artificial breeding cages (tiles) in the Insectary, died out after about four months, by which time adult workers and soldiers had been obtained. One colony, however, which had been planted out in a cage in the ground in the Insectary compound, could be traced for a whole year, after which it dwindled away; even after this period, however, the queen showed no particular sign of a dilated abdomen.

The habits of *Metriona circumdata*, *Aspidomorpha indica*, and *Philemostoma trilineata* were observed throughout the year. The beetles hibernate and live for about six months.

The life-history of *Ancylolomia chrysographella* was also traced throughout the Cold Weather (November-February). This moth hibernates in the larval stage and breeds continuously in the Hot Weather.

Two tube-forming Tineid larvæ, *Melasina* sp. and *Myrmecozela leontina*, both with only one brood in the year, were also under observation.

The life-history of *Leucophlebia lineata* (Sphingidæ) was traced throughout the year. The larvæ were noted to hibernate as well as æstivate.

Oides bipunctata (Chrysomelidæ) has been observed to hibernate and æstivate in the egg stage.

Polytela gloriosæ (Noctuidæ) has been observed to hibernate and æstivate in the pupal stage.

The already known habit of larval æstivation in *Mudaria cornifrons* (Noctuidæ) was confirmed by further observations.

In connection with other experiments on *Bactrocera cucurbitæ* (Trypaneidæ) it was noted that this Fruit-fly is capable of living in confinement in the adult state for a period of over three months. Under natural conditions it seems probable that many Fruit-flies live over from season to season in the adult state. It was also noted that stems of Cucurbitaceous plants and galls thereon, caused by Cecidomyiadæ or otherwise, were as favourable breeding-places for these flies as the fruits themselves.

In addition to the foregoing, complete cycles were observed of *Danais plexippus* (on *Oxystelona esculentum*, a new food-plant), *Kolla mimica* on paddy, a Jassid bug on sugarcane leaves, another Jassid on leaves of *Cyperus rotunda* (*Mutha*), *Polia consanguis*, a Halticid beetle on *Anisomeles ovata*, and *Cyrtacanthacris ranacea*.

A few broods from known parents were reared of *Terias hecabe* and *Papilio polytes* to ascertain proportional variation.

Further observations were made on the habits of *Tenebroides mauritanicus*, *Odoiporus longicollis*, *Attagenus piceus*, *Lepisma* sp., *Chilo simplex*, *Laspeyresia pseudonectis* and many other insects. Special attention was paid to leaf-mining Lepidoptera and numerous species, including many hitherto undescribed novelties, were bred out from crops and other plants.

Unsuccessful attempts were made to breed *Nephotettix bipunctatus*, *Zonabris pustulata*, *Lytta actæon*, and *Heliocopris bucephalus*.

Large numbers of Fruitflies were reared out to discover to what extent they are checked by parasites but it was found that the proportion of parasites is extremely low. The only Fruit-fly which is parasitized to any appreciable extent is *Carpomyia vesuviana*, whose larvæ feed in fruits of *Zizyphus jujuba*. About 800 pupæ of this fly were sent to Italy, to endeavour to introduce the parasite there, but owing to postal delays they failed to reach their destination alive.

Insecticides.—A series of experiments was carried out to test the effect of poisoned sprays on Fruit-flies, the species used being *Bactrocera cucurbitæ*. It was found that a spray of *gur* (sugar) and Lead Arsenate killed the flies in the course of about 36 hours. A similar mixture of *gur* and Lead Chromate had practically no effect and proved quite useless as a poison.

Protection of Timber against Termites.—The trials under this heading were continued. Further tests of Powellized wood and of Microlineum were made. Preliminary tests of Sideroleum were made, further tests being held in abeyance pending receipt of more material promised by the Agents of this preparation. Tests of Timborite were put in hand.

Grain Storage Experiments.—The storage of wheat, rice and pulses, commenced last year, has been undertaken this year on a larger scale based on the first year's results. In addition, in order to determine the pests of stored products more exactly, over sixty different substances have been placed under ordinary storage conditions for observation of their insect pests.

As a result of the first year's experiments, the lime treatment of rice has been found most satisfactory, the stored rice being rendered practically immune from all pests without impairing the edible qualities It must, however, be noted that the preliminary experiment was done on a very small scale and further tests on a larger scale are now in hand to check this result. The same remark applies to several other samples of wheat and pulses treated in different ways, and all are being retested on a larger scale. One curious case may, however, be mentioned here as at present it seems rather inexplicable; a jar of wheat grains infested with *Calandra oryzæ* had about half-an inch in depth of dry sand spread evenly in a layer over the top of the wheat; in due course the weevils emerged and made their way up through the sand which, however, they seemed unable to penetrate again, and all the adult weevils died and formed a layer on top of the sand, leaving the underlying wheat grains unaffected by any further weevils. At first sight it seemed that the experiment had been successful and that a simple layer of dry sand would form an efficient protection for wheat stored either for sowing or for food; but, on testing, this wheat failed to germinate. It was closed up in a glass jar: but so were other samples, equally, more, and less affected by weevils, and kept in exactly similar jars; yet these other samples germinated successfully. A duplicate lot, stored under sand in a porous earthenware vessel, also failed to germinate. Further experiments are being made with coarse and fine sand.

Bees.—Experiments with *Apis indica* were continued. The Wax-Moth (*Galleria mellonella*) gained entrance to the hives at an unexpected period (December) and destroyed five out of seven colonies; other colonies were procured but these were a little too late for the honey flow.

One colony of *Apis indica* was specially worked (1) to check swarming and (2) to attain the maximum yield of honey. Swarming was checked successfully and the yield of surplus honey was 15½ lbs., *i.e.*, about double the ordinary quantity. The result was attained by improved methods and an adequate supply of ready-made combs at the proper time. Work on these lines will be continued.

No further experiments have been made with European Bees owing to the great danger of introduction of Isle-of-Weight Disease into India. In

this connection a word of warning may well be issued to any would-be importers of European Bees.

Lac.—The emergence of Lac larvæ took place at Pusa on 30th September 1915 and 12th June 1916, and sixty large *Ber* trees were inoculated.

Numerous inquiries for Brood-lac, etc., were dealt with during the year.

Silk.—The Univoltine Mulberry silkworm eggs which were sent to Shillong and Muktesar for cold storage gave satisfactory results on rearing in March, but those sent to Guindy for rearing in October were not successful. Some of the hybrid multivoltine races, which have been under selective rearing during the last four years, were reared on a large scale and gave satisfactory results, the outturn of reeled silk in all cases being superior to pure multivoltine races but inferior to univoltines.

A Bengali translation of Bulletin No. 48 (First Report on Mulberry Silk Experiments) was printed during the year, and a second edition of Bulletin No. 39 (Instructions for rearing Mulberry Silkworms) is now in the press. A second Report on the Mulberry Silk Experiments has been written up. Articles on Mulberry Silk were also contributed to the Bengali Journal " Grihastha."

Some experiments were carried out with *Tricolyga sorbillans*, Wied. (*bombycis*), the *Tachinid* parasite of silk-worms, in connection with its method of oviposition and breeding-habits. The following caterpillars were exposed to attacks of the flies, *viz.* :—Mulberry silkworms (*Bombyx mori*), Eri Silkworms (*Attacus ricini*), *Achæa janata, Spodoptera mauritia, Polytela gloriosæ, Cosmophila sabulifera, Papilio demoleus, Utetheisa pulchella* and *Diacrisia obliqua* of which the last two are hairy and the others smooth-skinned. The flies were found to oviposit on all the varieties of caterpillars, whether hairy or smooth, but could not breed in other caterpillars so successfully as they could in the silkworms. Flies were actually bred out only from the parasitized larvæ of *Cosmophila sabulifera* but from the experiments it appeared that the flies could, if necessary, breed in the other caterpillars.

Illustrations.—Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.* :—*Pachydiplosis oryzæ,* Papua depessella, Phyllocnistis citrella, Chloridea assulta,* Kolla mimica, Oedematopoda clerodendronella, Epicephala chalybacma, Terias hecabe,** of which those marked * are now in press and will be available shortly.

A coloured plate of orange fruits was also prepared for the Agricultural Officer, North-West Frontier Province. Besides the completed coloured plates, a large number of figures in colour and line was drawn of various insects and these will be utilized for publications in due course.

A list of all the Coloured Plates of Indian Insects, prepared to date, was issued during the year, mainly for the information of Provincial Entomological Staffs. This list shows for each insect whether the coloured plate has been printed and, if published, in what publications it has appeared.

The issue of coloured plates and lantern slides has been continued.

Insect Survey.—Steady progress has been made in additions to and arrangement of the Collection. The whole of the Collection of Lepidoptera has been overhauled, rearranged and placed in one series, so that all the information on any species or group is now available in one place. The same is being done with the Coleoptera, which are nearly finished, and other groups will be taken up as time and staff permit. Work of this sort takes time and care, but is necessary as, in the not infrequent case of non-identification or misidentification of an insect at the time of its collection or occurrence as a pest, the specimen itself forms the only evidence of its identity and if it is hidden away, out of the series, as a "duplicate" or "non-identifiable," valuable information may easily be overlooked.

The Collections continue in good order but the difficulty of maintaining them, in boxes in open racks in a climate such as that of Pusa, is very great.

The following collections were sent out to Specialists in the groups named and our thanks are due to them for the help afforded :—

(i) Micro-Lepidoptera to Mr. E. Meyrick, F.R.S., to whom special thanks are due for his examination of the whole of our unnamed material, of which about forty *per cent*. proved to be new to Science. The novelties are under description in "Exotic Microlepidoptera." A Memoir on life-histories of Indian Microplepidotera, comprising all the information published hitherto together with a mass of new material now rendered available by the identifications received, is now in preparation.

(ii) Rhynchota to Mr. W. L. Distant. Much of the new material has been utilized in Volume VI of *Rhynchota*, lately published in the "Fauna of British India" series. Some of our material has been received back.

(iii) Rutelidæ to Mr. G. J. Arrow, who will use this material for his "Fauna" volume on this group. Specimens returned, named.

(iv) Carabidæ to Mr. H. E. Andrews, who is working on the Indian species of this group. Partly returned, named.

(v) Trypaneidæ to Professor Mario Bezzi of Turin. The specimens were named and we were advised of their return, but they have not been received and were presumably lost in the S.S. "Persia." Types of eight new species had fortunately been sent direct to the British Museum by Professor Bezzi.

(vi) Parasites of Trypaneidæ to Professor Silvestri, Portici, Italy. Not yet returned.

(vii) A Dryinid parasite on nymphs of *Pyrilla* spp. to Mr. J. C. Crawford. Named as *Chlorodryinus pallidus*, Crawf.

(viii) Cecidomyiadæ to Professor E. P. Felt. They have been named and the collection retained for the present.

(ix) Sphegidæ to Mr. Rowland Turner. Not yet received back.

(x) Apidæ to Mr. G. Meade-Waldo, whose recent untimely death has deprived us of a most valued correspondent who was always willing to give us every help in identification of our specimens. This collection remains at the British Museum and will probably be transferred to Professor Cockerell for examination.

(xi) Curculionidæ to Mr. G. A. K. Marshall. Partly named and returned.

(xii) Cerambycidæ to Mr. C. J. Gahan. Not yet returned.

(xiii) Histeridæ to Mr. Lewis. Not yet returned.

(xiv) Coccidæ to Mr. E. Ernest Green. Partly named and returned.

(xv) Diptera (various groups) to Mr. E. Brunetti, who has taken much time and trouble in affording us help.

(xvi) Towards the close of the year the manuscript of a paper descriptive of a collection of Indian Termites, sent in 1912-13, was received from Professor Nils Holmgren, of Stockholm. This paper is written in German and will require translation before publication. It contains descriptions of numerous new species and the issue of these will enable a mass of notes on these species to be written up for publication.

(xvii) Examples of *Stibaropus minor*, Wlk., found in an Ant's nest were sent to Mr. Donisthorpe, who, however, considered that they were not myrmecophilous insects.

(xviii) A collection of *Rhogas* spp. was sent to Mr. C. T. Brues, United States America, for identification and description of the new species.

(xix) A mite found attacking the cocoons of a Burmese Ant, *Ectatomma coxale*, was sent for examination by Mr. S. Hirst, who writes that it is a new species of the genus *Urodinychus*, Berlese. Some species of this genus are known from Europe, a few from Africa and one from Java, and of these some have been found in ants' nests but very little is known about their habits.

Various collections of Indian Insects have been received and named and returned as far as possible ; these included (i) a collection of Rhynchota from Mrs. Kilby, (ii) Microlepidoptera from Coimbatore Agricultural College, (iii) Insects from Birds' stomachs sent by the Nagpur Museum, (iv) various insects from Nagpur Agricultural College, (v) various insects from Entomological Assistant, Burma, (vi) collections of Hymenoptera, Lepidoptera, and Rhynchota from Mr. C. Inglis, besides numerous other small sendings.

II.—Work in the Provinces.

Madras.—Numerous crop-pests were dealt with during the year, and included :—(1) a bad outbreak of *Rhizopertha dominica*, Fb., on stored paddy in Chingleput and South Arcot Districts in July-August. Several infested

granaries of the ryots in these tracts were fumigated with Carbon Bisulphide with appreciable success. Fumigation with Hydrocyanic Acid gas is being tried for stored products pests on the farms. (2) *Idiocerus spp.* on mango. In view of the encouraging results obtained last year spraying experiments on a larger scale were arranged during the mango season 1915-16 in the important mango districts of Salem and Chittoor and the results have proved very encouraging and orchardists appear eager to adopt spraying as a routine seeing that the measure brings in additional profit. Fish Oil soap was found very effective. (3) Serious damage to young cinchona plants by white grubs was reported from the Government Plantations, Nilgiris, in September. With a view to note the exact time of emergence of the beetles an investigation of the species concerned and their life-histories and habits was begun and is being continued. Light traps in May-June attracted hundreds of beetles. Three or four species were found to be chiefly concerned, *viz.* :—*Holotrichia* spp., *Popillia chlorion* and *Serica nilgiriensis*. Eggs were obtained in captivity and the period of one generation is being studied with a view to note the exact time of emergence. Light traps during the early rains in May-June appear to be very effective. (4) The rice grass hopper, *Hieroglyphus banian*, did some damage to paddy in Malabar and bagging demonstrations were appreciated. (5) *Hispa armigera* was reported from parts of Salem on paddy and also received the same attention. (6) *Batocera rubus*.—Trees badly attacked in two or three gardens at Coimbatore and elsewhere were successfully treated by syringing with Creosote-Chloroform mixture. (7) Investigation of crab attack on growing young paddy occupied some time. The crabs were of the species *Paratelphusa hydrodromus* and fed on young paddy shoots and leaves in the Tanjore and Krishna deltas in August.

The life-histories of various insects were worked out in the Insectary and amongst these may be specified *Oxya velox*, *Epacromia tamulus*, *Contheyla rotunda*, *Cirphis albistigma*, an *Erotylid beetle* on Tenai (*Setaria italica*), *Pachytychius mungonis* (Green Gram weevil), Anaikombu fly on paddy (probably *Pachydiplosis oryzæ*).

Bombay.—Two Entomological Assistants are employed in Bombay, one at the Agricultural College at Poona, the other at Nadiad Agricultural Farm.

At Poona the fruitfly *Dacus zonatus* was studied and found breeding in fruits of mango and of *Citrus decumana* and *C. medica*, the grubs confining their attention only to the spongy skin of the Citrus fruits. The flies commenced to appear in the last week of March. It was found that the male flies were attracted to a distillate of flowers of *Ocimum sanctum* and could thus be caught by a sticky paste of Fir-tree resin and machine oil boiled together, as many as 1,415 flies being caught on one day in the middle of June ; but it is doubtful whether any method, attractive to the males only, has much effect on control of damage. Pomelo fruits at Chimbur, near Bombay, were attacked by moths of *Ophideres fullonica*, nearly half the crop being spoilt ; attraction to a fermenting mixture of sugar and toddy was tried with some result, as also burning off the moths with a lighted torch

whilst they were sucking the fruit. Further studies were made of *Aphanus sordidus*, a bug which attacks ground-nut pods; the best method of control appears to be by burning them on the boundaries of the field before the crop is harvested, the expense of this method being Rs. 3-12-0 per acre.

At Nadiad the principal crop-pests dealt with included :—(1) Hairy Caterpillars (*Amsacta moorei*), successfully checked by hand-picking, bagging and attraction to light-traps. Of 1,701 moths, attracted to light, 400 were females. (2) *Lytta actæon* appeared in large numbers during the second week of May 1916 and commenced to damage lucerne; they were all hand-picked, to the number of about 2,400 from one acre of lucerne, at a cost of 2½ annas. (3) *Epacromia tamulus* appeared in the beginning of October 1915 and were checked by light traps, in which 7,345 grass-hoppers were caught in a week, no attack on young juar seedlings developing thereafter. (4) *Hispa armigera*, prevalent on Kharif Juar in the Surat District during the monsoon; controlled by bag-nets swept over Juar seedlings. (5) *Hieroglyphus banian* occurred in large numbers near Dhulia in a restricted area under canal irrigation and was controlled by bagging. (6) *Leucinodes orbonalis* did considerable damage in Gujarat by boring in Brinjal shoots and fruits and was controlled by destruction of affected shoots and fruits. (7) Experiments were made on fumigation and preservation of stored seeds. (8) Northern Gujarat was invaded by locust swarms in the last week of June 1915 but apparently no eggs were laid in Gujarat. The swarms came from Rajputana and the Central India Agencies and went towards the Ran of Cutch.

Central Provinces.—The main work of the year was devoted to the outbreak of "Maho" (*Nephotettix bipunctatus*), already noted under Part I. Collection by means of bag-nets, consisting of a cotton cloth bag 4 feet long attached to a rectangular framework, 6 by 4 feet, made of light bamboos was found to be most effective. Large numbers of these were made and used with considerable success and whether owing to these measures or to the heavy rains about the end of August, there was an almost complete cessation of the pest by the middle of September, apparently before the insects had become adult. Some work was also done on borers of orange trees, *Stromatium barbatum* and *Arbela sp.*

United Provinces.—Experiments in the storage of seed wheat and of potatoes were carried out. Records were kept of the occurrence of Bollworms (*Earias* and *Gelechia*) and their parasites at different seasons of the year.

Punjab.—Collection of Sugarcane Borers was continued to ascertain the species concerned; irrespective of this, from a practical control view-point, it was found that cutting out of "dead hearts" proves equally effective against all borers attacking young canes. The year 1915 was not a "Boll-worm" year and American cottons remained free from attack throughout the season, but *desi* cottons suffered from drought and in October and November the few bolls found were attacked fairly extensively. All cotton-growing districts were supplied with large quantities of *Rhogas* spp., parasitic on Boll-

worms (*Earias*). Experiments were done on control of Mango Hoppers (*Idiocerus* spp.) but were not wholly successful, the non-success being apparently due to the non-separation of treated trees and controls. Melon Fruit-fly was checked by destruction of the first-attacked fruits in April and May, the main crop being saved.

Sericulture is progressing in the Punjab, and in the season 575 ounces of French Mulberry silkworm eggs were distributed. From 175 ounces distributed by the Entomological Staff, 165¾ ounces to village families and 9¼ ounces in small lots to 32 village Primary Schools, were obtained only 23 maunds 25 seers of dry cocoons, the rearing being bad because the seed was pebrinized and the season unfavourable on account of failure of the winter rains, so that the mulberry leaves available were poor and tough.

North-West Frontier Province.—The discovery of *Dacus oleæ* in olive fruits has already been alluded to in Part I. Experiments in storage of grain, according to local methods, were started. The results of considerable experience with spraying in fruit orchards may be summarized as follows :—(1) In irrigated orchards, with Indian labour, a good type of pneumatic sprayer, equipped with extension rods and having a working capacity of about 4 gallons, is more economical than the older types of knapsack or barrel sprayers and also gives most thorough treatment to the trees with least discomfort to the men employed in spraying. (2) The cost of treating 100 full-grown peach trees with various sprayers and insecticides has worked out as :—

Type of Sprayer.	Kerosine Emulsion.	Katakilla.	Vermisapon.
	Rs. A. P.	Rs. A. P.	Rs. A. P.
Holder Pneumatic	7 2 0	8 4 0	9 15 0
Four Oaks Knapsack	8 0 0	9 4 0	11 0 0
Anto-Spray	9 12 0	11 2 0	13 2 0

Bihar and Orissa.—The following important crop pests were dealt with, *viz.* :—on paddy, *Hispa armigera*, *Spodoptera mauritia*, *Nymphula depunctalis*, *Ripersia sacchari* ; on juar, *Stenachroia elongella* ; on pulses, *Agrotis ypsilon*, *Diacrisia obliqua*, *Plusia orichalcea*, *Agromyza sp.*; on jute, *Cosmophila sabulifera*, *Diacrisia obliqua* ; on sugarcane, *Hieroglyphus banian*, *Termes sp.*, *Scirpophaga auriflua*, and moth borer ; on castor, *Chrotogonus trachypterus* ; on tobacco, *Agrotis ypsilon* ; on potato, *Agrotis ypsilon*, *Phthorimæa operculella*, and *Euzophera perticella* ; on vegetables, Green fly ; on mango, *Dacus persicæ* ; on jak fruit, *Monophlebus stebbingi*. Stored grains :—796 maunds 23 seers of stored grains, mainly Pusa wheat and paddy, were fumigated with Carbon Bisulphide in the Sabour Farm godown.

A campaign was conducted on a large scale against *Agrotis ypsilon*, on Rabi crops at Ghogha and Colgong. Fifty-six improved Andres Maire

traps were used and they accounted for the destruction of 4,37,956 parent moths of which 2,12,355 were females. The total number of caterpillars destroyed during the season was 1,33,443. The result of the campaign was very satisfactory as the total damage amounted to 75 acres only.

With a view to finding out the æstivating conditions of *Agrotis ypsilon*, an Assistant was deputed to the attacked area where he remained from March onwards. The insect was nowhere found in any one of its stages in the neighbourhood of the affected area. Experiments conducted in the Insectary at Sabour appear to indicate that it was not possible for the insect to remain, at least in the plains to the south of the Ganges, during the summer months when the temperature and moisture conditions are very trying.

Bengal.—The Entomological Collector toured in connection with outbreaks of *Cosmophila sabulifera* on jute, *Nephantis serinopa* on palms, and *Schœnobius bipunctifer* and *Hispa armigera* on rice. Experiments to check Mango Weevil by Kerosine treatment were continued.

Assam.—The Entomological Assistant was chiefly employed in checking outbreaks of pests particularly of paddy.

Burma.—The study of the insect pests of paddy was continued and the results summarized in a Bulletin. Further work on pests of stored paddy was also done. Fumigation of stored seeds with Carbon Bisulphide was carried out successfully.

Part III.—Native States.

Kashmir and Baroda.—No scientific work was done during the year under review.

Hyderabad.—There is at present no Entomological Section of the Agricultural Department, which has however carried out some control work on insect pests and published a few notes on Entomology for use of its Field Staff. Sprays and insecticides have been introduced and have proved successful in small trials against grasshoppers and rats.

Mysore.—The life-histories of three Scale-insects (*Coccus viridis, Lecanium hemisphæricum* and *Pulvinaria psidii*) have been worked out. Work has also been done on the life-history of *Xylotrechus quadripes*. A *Scarabæid* beetle pest attacking roots of paddy in the nursery and transplanted fields has been studied and a remedy devised. Against *Nymphula depunctalis* kerosining the water of the paddy-fields has been found an efficient remedy. *Simplicia robustalis* occurred as a pest of harvested *ragi*. The life-histories of all three species of *Idiocerus* on mango have been worked out. Experiments against *Bruchids* have shown that a little mercury placed in the store bin or basket checks, but does not prevent, the multiplication of the pest; this action is not understood and further experiments are in progress. A *Cecidomyiad* fly on *cholam* has been under investigation. Field work was carried out against *Coccus viridis* and *Amsacta albistriga*; demonstrations of the life-

history and means of control of the latter insect were carried out in 42 villages and nearly as many schools and 40,447 moths were hand-picked in six of these villages where organized work was carried out under Departmental supervision.

Travancore.—Field work was carried out against *Leptocorisa varicornis* on paddy by collection in hand-nets; against *Spodoptera mauritia* on young paddy by raising the water-level to about five inches, oiling the water and dragging a bamboo over the plants; against a Limacodid larva on coconut palms by spraying; against *Oryctes rhinoceros* in coconut palms by application of sand and salt (10 : 1) to the crown of the tree; and against *Rhynchophorus ferrugineus* in coconut palms by destruction of affected trees. A bulletin on pests of Coconut was published.

Part IV.—Other Entomological Work.

Indian Tea Association.—Experiments were carried out in connection with the control of the Tea Mosquito (*Helopeltis theivora*), with a view to ascertain whether the liability of tea bushes to attack can be influenced by the addition of soluble plant foods to the soil. These experiments have given interesting results which show that this can be done, though they have not yet reached the stage at which recommendations can be made with absolute certainty of success. The results of this work are about to be published. The study of the Termites of South Sylhet, and of their depredations in tea, received attention during the cold weather of 1915-16, and an account of the results obtained has appeared in Part II of the Quarterly Journal of the Department for 1916. Some time was given, during May and June, to the study of the Thrips insects which damage tea in the Darjiling district, and all the stages of the common Thrips have been worked out, and most of the stages of the Black Thrips. Trials of different insecticides were carried out with marked success. The results of this work are in preparation for the press. The investigation of the pests of Green Manures and Shade Trees in use on the tea gardens of North-East India has been carried on throughout the year, and two parts of a series of articles on the subject have been published in the Quarterly Journal of the Department. A great deal of advisory work has also been carried out during the year, and in addition to routine work at Head-Quarters, touring has been carried out in this connection, in the following districts. The North Lakhimpur, Bishnath, Tezpur, Dibrugarh, and Doom Dooma district of Upper Assam; The Happy Valley, Lakhimpur and North Cachar districts of Cachar; the Balisera and Luskerpore valleys of Sylhet; the Terai, Darjiling, and the Duars.

South Indian Planting Districts.—With regard to the outbreak of Green Scale-bug (*Coccus viridis*) on Coffee Estates, spraying operations have been generally carried out and the planters are quite alive to the danger of allowing this pest to spread; last season the rain which fell during nearly every month of the year favoured the growth of the fungi parasitic on this

scale and it was largely kept in check by these natural means and did not spread to any extent. The present season has not been so favourable and it has been reported from a number of places and appears to be gradually spreading.

Owing to the increase in price of European Flour on account of the War a cheaper substitute was required for a spray against Red Spider and a mixture of Imperial Insecticide Bar Soap (2 lbs.) with Flowers of Sulphur (3 lbs.) in 4 gallons of hot water, diluted to 40 gallons and with a little crude kerosine oil added, was found quite efficacious (see *Planters Chronicle*, Vol. X, p. 560).

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" " . A Catalogue of new Wasps and Bees described from the Indian Region since 1897. (*l.c., pp. 539-560.*)

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" . . A swarm of Locusts in the Darjeeling and Terai Districts. (*l.c., pp. 63-67.*)

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TRAVERS, W. LANCELOT. Locusts in North Bengal. (*Bombay Nat. Hist. Soc. Journ., xxiv, 197-198.*)

TYTLER, H. C. . . Notes on some new and interesting Butterflies from Manipur and the Naga Hills, Part III. (*Bombay Nat. Hist. Soc. Journ., xxiv, 119-155, tabs. 3, 4.*)

ULMER, G. . . . Trichopteren des Ostens, besonders von Ceylon und Neu-Guinea. (*Deut. Ent. Zeits, 1915, 41-75, figs.*)

WALL, F. . . . Gulls feeding on Termites. (*Bombay Nat. Hist. Soc. Journ., xxiv, 598*).

WATERSTON, J. . . New species of Chalcidoidea from Ceylon. (*Bull. Ent. Res. v, 325-342.*)

WILLIAMS, C. B. *Thrips oryzæ*, sp. nov., injurious to Rice in India. (*Bull. Ent. Res., vi, 353-355, figs.*)

Part II.—Forest Entomology.

BY

N. C. CHATTERJEE, B.Sc.

Assistant to the Forest Zoologist.

Sal Insects.—No touring was done during the year in connection with the investigation. Of the Shot-hole and pinhole borers belonging to the families *Platypodidae* and *Ipidae*, which cause technical damage to sal, some twenty-five species have been under observation in the Insectory at Dehra Dun and the economic status of the majority of species has been worked out. One species of shot-hole-borer, *Diapus furtivus*, Sampson, which has acquired a certain amount of notoriety in connection with the death of sal in Bengal, has been studied and an account of its life-history and economic importance has been written and submitted for publication. It was originally proposed to record the results of the enquiry in the form of a memoir on the life-histories of the shot-hole-borers of sal, but the war has rendered this impossible.

The life-history of the salheart-wood borer, *Hoplocerambyx spinicornis*, Newm, has been under observation in the Siwalik Division, United Provinces. In the Insectary, Dehra Dun, *Hoplocerambyx spinicornis* has been reared from the egg. The complete life cycle occupies only one year. An account of its life-history will be drawn up shortly and submitted for publication.

A large amount of material has been collected on the life-histories of the small longicorns of sal, where opportunity offered, and the life-history of

Aeolesthes holosericea, Fab., an equally important sal longicorn, is under observation. Only the egg and early larval stages have as yet been studied.

Teak Insects.—The Bee-hole borer. No touring was done during the year in connection with this investigation, but field-work was carried out by Mr. A. Rodger, Forest Research Officer, Burma, throughout the year and a number of observation plots have been established. The egg and early larval stages of *Duomitus ceramicus* wlk, are being studied and the constancy of the local incidence of the borer is being determined. Notes and observations on the life-history of this borer are being sent in from different observation areas and specimens of larvae and larval work have been received from several divisions. Steps are about to be taken to collect data on the extent of the loss due to the bee-hole borer in different localities in Burma. In this enquiry it is hoped to enlist the co-operation of the lessees of the Burma Teak Forests.

The life-history of the longicorn beetle, *Haplohammus cervinus*, Hope which is responsible for cankerous swellings and fissures on the stems of teak poles and saplings, is being studied. A series of these beetles have been reared from stems received from the Sitapahar Range, Chittagong Hill Tracts Division.

Sundri Insect.—No tour was proposed this year. The results of preliminary enquiries tend to show that the effects of the 1909 cyclone on the incidence of the insect-fauna of Sundri (*Heritiera Fomes*, Buch.) were very small and resulted in no extensive out-break of any one species. The borers of Sundri include five species of Longicorn and Buprestid beetles, three species of Platypodid shot-hole borers and three species of Ipid pin-hole borers. Of these the *Platypodidæ* only are able to cause serious technical damage to timber, but no one of the species of Sundri insects appears to be of primary importance or able to attack a perfectly healthy tree. The death of Sundri trees in small groups near water channels in the Sunderbans is due to a disease of the roots. The investigation is being continued.

Chir Pine Insects.—No touring in connection with bark beetles of Chir-pine or other conifers was undertaken during the year. In the Naini Tal Division progress was made with the life-history studies of the Chir Scale-Insect, (*Ripersia resinophila*, Green) and measures for affecting a control on the rate of increase of this pest have been devised. The observation plots established last year were re-examined in February-March and additional similar areas have been laid out.

Toon Shoot borer.—The seasonal history of *Hypsipyla robusta, Mo*, has been studied and the number of generations in a year has been determined. Sack-banding of the older trees, combined with early pruning in plantations, has proved an efficient method of control of this borer. During the first (flower) generation 900 trees were sack-banded in April and about 50,000 larvae and pupæ were collected from underneath the sack-bands. In the

second (fruit) generation this number was reduced to 20,000. An account of the life-history of the borer is being prepared for publication.

Miscellaneous pests.—Reports of pests and enquiries from forest officers have been more numerous than usual and include several new records.

The Divisional Officer, Bashahr, Punjab, sent in specimens of *Pinus excelsa* attacked by *Polygraphus major*, Steb. From the Chamba Division, Punjab, specimens of *Pinus longifolia* wood attacked by *Polygraphus major*, Steb, *Crossotarsus* sp and *Cryptorhynchus* sp, were received. The Cockchafer grubs which attack deodar seedlings, sent by the Divisional Officer, Bashahr, last year have been identified as belonging to *Protaetia neglecta ;* a Cetonid chafer. From the Instructor, Forest School, Kashmir, bark and wood specimens of deodar infested with *Ips ribbentropi* Steb., *Eccoptogaster major*, Steb., *E. deodara*, Steb., *Crossotarsus* sp., *Cryphalus* sp. and *Tetropium oreinum*, Gahan, have been received. From the Divisional Officer, Gonda, United Provinces, specimens of shisham leaves from an experimental nursery, damaged by *Myllocerus* sp., were received. From Gorakhpur Division report of damage to leading shoots of sal by *Monophlœbus stebbingi*, was received. The Divisional Officer, Gorakhpur, sent a Prionid larva attacking roots of sal. The Divisional Officer, Pilibhit, sent in culms of Ulla grass attacked by Pyrallid, Cossid and Longicorn larvae. From the Superintendent of Forests, Marwar State, Jodhpur specimens of Jamun leaves damaged by a Microlepidopterous caterpilllar were received. From Virajapett, Coorg, sandal seedlings infested with a species of Coccid, ? *Lichtensia* sp. were received. Mr. C. C. Wilson, Working Plans Officer, Vellore, Madras, reported extensive damage to young sandal saplings due to *Zeuzera Coffeae*, and an unknown Lamiid borer. The Divisional Officer, Ganjam, Madras, sent a sal defoliator which has been identified as *Ingura subapicalis*, Wlk. The Divisional Officer, Belgaum, Bombay, sent specimens of grubs which were reported to be doing much damage to Teak in a nursery. The grubs proved to be of *Oryctes rhinoceros*. The Conservator of Forests, Bihar and Orissa, sent specimens of *Acacia Donaldi*, the seeds of which had been damaged by *Caryoborus* sp. From the Divisional Officer, Chittagong Hill Tracts, pupa and moth specimens of *Hybloea puera*, defoliating plantation-grown Teak were received. From Buxa Division reports of defoliation of Khair and Sissoo by Geometrid, Lymantrid and Bombycid caterpillars were received. The Divisional Officer, Buxa Division sent specimens of an unknown Prionid larva attacking Dalbergia sissoo roots. Reports of damage to *Michelia excelsa* in plantations by an Aphid, *Lachnus* sp., were received from the Divisional Officer, Darjeeling. Beetles attacking the branches of Nahor (*Mesua ferrea*) sent by the Divisional Officer, Tista Division, in 1910, have been identified as *Xyleborus discolor*, Bldf. and X. *interjectus* Bldf. The Lasiocampid Khasya-pine, defoliators received from Mr. A. W. Dentith, Deputy Commissioner, in charge Khasya and Jantai Hill Forests, have been identified as *Metanastra latipennis*, Wlk. and *Lebeda nobilis*, Wlk. The Divisional Officer, Arakan Division, Aykab, sent in specimens of Teak stems showing cankerous swellings caused by *Haplo-*

hammus cervinus, Hope. From Thaungyin Division, Burma, specimens of larva and pupa of *Hybloea puera*, defoliating Teak, were received. The weevils attacking Teak saplings, sent by the Divisional Officer, Ruby Mines Division, in 1913, have been identified as *Alcides ludificator*, Fst. The Divisional Officer, Myitkyina Division, sent specimens of *Haplohammus cervinus*, Hope, and an unknown Cerambycid borer reported as doing much damage to young Teak in the Indawgyi Reserves. Mr. A. Rodger, Forest Research Officer, Burma, sent a Cerambycid beetle, bred out from the heart wood of *Xylia dolabriformis*, which was identified as *near Pachydissus parvicollis*, Gahan. The Instructor, Forest School, Pyinmana, Burma, sent specimens of *Bombax malabaricum* leaves, from the School nursery, severely damaged by a weevil, *Tanymecus* sp. The Working Plans Officer, Pegu Division, Burma, sent in specimens of *Phœnix paludosa*, attacked by *Protocerius grandis*, Guer. The weevils doing damage to young Padauk sent by the Deputy Conservator of Forests, Andamans, in 1905 have been identified as *Trigonocolus brachmanae*, Fst.

Insect Collections.—A considerable portion of the collections have been rearranged and expanded and they are now in good order. Owing to the inaccessibility of most European specialists the additions of identified specimens have been much curtailed. The chief additions include identified materials returned during the year by various specialists, *viz.*, *Coprinae*, *Rutelinae* and *Melolonthinae* by Mr. G. Arrow; *Bombylidae*, *Trypetidae* and *Nemistrinidae* by Mr. E. Brunetti; *Curculionidae* by Mr. G. K. Marshall; *Anthribidae* by Mr. K. Jordan; *Asilidae* by Miss G. Ricardo; and a miscellaneous lot by Mr. T. B. Fletcher; to all of whom our thanks are due for the help afforded.

List of Publications on Forest Entomology during 1915-16.

IMMS, A. D. & CHATTERJEE, N. C. . On the Structure and Biology of *Tachardia lacca*, Ker, with observations on certain insects predaceous or parasitic upon it. (*Ind. For. Mem.*, *III, Pt. I.*)

BEESON, C. F. C. . *Ips longifolia*, Steb. as a pest of Chir regeneration areas. (*Ind. For., 317-325.*)

" . . Notes on some Indian Forest Beetles (*Ind. For., pp. 294-99.*)

" . . Ambrosia Beetles or Pin-hole and Shot-hole Borers. [Col. Fam. *Ipidae, Platypodidae.*] (*Ind. For., pp. 216-223.*)

GREEN, E. E. . . On a Coccid injurious to Pine trees in the Himalayas. (*Bull. Entom. Research, pp. 395-397.*)

VETERINARY SCIENCE.

BY

A. W. SHILSTON, M.R.C.V.S.,

Assistant Bacteriologist, in charge office of the Imperial Bacteriologist, Muktesar.

In addition to minor investigations, mainly connected with the examination of specimens received for diagnosis, the following research work was carried out during the year 1915-16 at the Imperial Bacteriological Laboratory, Muktesar.

Rinderpest.—The tests of the actions of drugs in the treatment of rinderpest were discontinued owing to failure to observe any appreciable beneficial effect on the course of the disease from their administration.

At the request of the Board of Scientific Advice the observations already in progress on the preservation of the rinderpest virus, were extended to include a more complete study of the duration of vitality of the virus under natural conditions. The opinions of various authorities differ widely on this point and it is very desirable that definite information should be obtained, in relation to the disease in India.

The observations will shortly be completed and a report submitted for publication.

With a view to improving the existing routine method of anti-Rinderpest serum manufacture, comparative tests were carried out of the values and yields of sera obtained from bleedings taken at varying intervals after injection of the rinderpest virus; alterations in respect of the number, volume and times of bleedings after each injection of virus were found to increase both the yield and potency of the serum and accordingly were adopted as routine measures. An account of the experiments has been submitted for publication. At the same time comparative tests of different procedures for separating the serum from the blood, were carried out and it was found that a new combined method of centrifuging and clotting gave larger yields of clearer serum than centrifugalization alone; this modification is now applied in the manufacture of all anti-sera. A report of the tests as applied to Hæmorrhagic Septicæmia and Anthrax sera has been submitted for publication by Dr. Norris.

Observations were made by Dr. Macalister on the application of serological methods to the determination of the potency of anti-rinderpest serum but so far the results have been negative, the only means of standardization at present available is inoculation of susceptible cattle simultaneously with virulent blood and varying doses of the serum but a more exact and less costly method would be very valuable.

Anthrax and Hæmorrhagic Septicæmia.—The experiments on the drug treatment of these diseases have been discontinued.

For both these diseases a means of conferring immunity of longer duration than can be obtained by the use of anti-serum or the present Hæmorragic Septicæmia vaccine, is urgently required but the necessary condition of perfect safety in application places a serious obstacle in the way of its attainment.

Vaccines prepared in various ways from cultures of the organisms have been tested and in certain cases the results have been encouraging, it is proposed to continue the experiments along these lines.

Observations begun by Dr. Macalister on the standardization of the antisera of these diseases, are still in progress but the investigation of certain biochemical questions in this connection has been interrupted by the temporary transfer of Dr. Norris to Military service.

Kumri.—The investigation into the etiology and pathology of this disease has been continued by Dr. Macalister. A preliminary report on the subject embodying the results obtained up to the present, is being submitted for publication.

Strangles.—A large number of inoculation experiments were carried out at the Army Remount Depôts at Mona and Sargodha, the results in many cases have been disappointing and serve to demonstrate the great difficulty of producing a sufficient degree of immunity in the highly susceptible young horses to protect them against infection on entering the depôts.

Certain methods have, however, been found more effective and will be tested further. The value of both serum and vaccines in the treatment of the disease and its sequelæ has been frequently demonstrated and these agents are now being largely used in the depôts.

Contagious abortion.—An outbreak of this disease amongst the mares of the donkey stud at the Remount Depôt, Mona, gave an opportunity for making a bacteriological examination of the condition. An organism was isolated which produces abortion in pregnant equines and guinea pigs ; in this and other characteristics it closely resembles the *bacillus abortivo-equinus* (Good and Smith) of equine contagious abortion in America.

There is no doubt that this organism was responsible for the outbreak of abortion at Mona and its further study, particularly in relation to possible means of producing immunity against its action, will be continued.

Surra.—Arrangements were made with Mr. Howlett, Pathological Entomologist of Pusa, to carry out a joint investigation of the transmission of surra by biting flies, but owing to his departure on leave the original programme could not be followed. However he kindly placed the services of his assistant, Mr. Patel, at my disposal, and with the help of this officer a number of interesting experiments were carried out at the Bareilly Laboratory. An account of these will be submitted for publication.

Tuberculosis.—Cultures of several strains of *B. tuberculosis* were obtained from natural cases of the disease in Indian bovines ; so far as is known, this had not previously been done. The material for the purpose was kindly sent in by Mr. G. Taylor, Superintendent, Civil Veterinary Department, Punjab. The cultural and other characters of the various strains will be studied for the purpose of determining to which variety of the organism they belong ; this point is of importance in relation to both human and bovine tuberculosis in India.

Reports from Veterinary Colleges and Provincial Laboratories.

The Punjab Veterinary College, Lahore.

The Principal of the College, Colonel H. T. Pease, C.I.E., reports that experiments have been carried out by Mr. Taylor in connection with the anti-rabic inoculation of dogs bitten by rabid dogs, on the same lines as those in use at the Pasteur Institute, Kasauli ; these are being continued. Experiments have also been made in the treatment of Dourine.

Camel specialist.

The annual report of the Camel Specialist, Mr. H. E. Cross, for the year 1915-16 contains details of further experiments to test the repellant effect on biting flies of various mixtures when applied to the skin of camels, also observations on the susceptibility of camels to Black Quarter and Hæmorrhagic Septicaemia. Descriptions are given of the diseases Sore throat, Jhooling and Wail, of which the causes are at present unknown. Observations on the drug treatment of Surra in camels and the course of camel surra in horses, goats and sheep are recorded.

Civil Veterinary Department, Madras.

The Superintendent, Mr. F. Ware, in a note on " The possibility of Amoebic Dysentery in the Dog and its Treatment," submitted to the Commissioner of Revenue and Agriculture, Madras, describes the finding of amœbaein cases of dysentery among the hounds of the Ootacamund pack and the successful results obtained from treatment with Emetin.

A list of papers published during 1915-16 bearing on Indian Diseases.

ACTON, H. W. & KNOWLES, K. — Studies on the Treatment of Snake Bite. (*Ind. Journ. Med. Res.* [*1915*], *iii, 259.*)

BROWN, H. C. & KIEWAN, E. W. — Standardisation of Bacterial Suspension by Opacity. (*Ind. Journ. Med. Res.* [*1915*], *ii, 763-769.*)

CORNWALL, J. W. & IYER, S. K. — Arneth's Index and Anti-rabic Treatment. (*Ind. Journ. Med. Res.* [*1915*], *iii, 132-134.*)

COOPER, W. F. & LAWS, H. E.	Some observations on the Theory and Practice of Dipping. (*Parasitology [1915], viii, 190-217.*)
DE MELLO, F. . .	Preliminary note on a new Homogregarine found in the Pigeon's Blood. (*Ind. Journ. Med. Res., iii, 93.*)
GAIGER, S. H. . .	Treatment Nematode Diseases. (Veterinary Record, xxvi [1915], 128.)
GAIGER, S. H. . .	Glanders in man. A Second attack after apparent Recovery. (Journal of Comp. Pathology and Therapeutics, xxix [1915], 26.)
GUPTA, M. C. . .	Anthrax in Elephants. (Veterinary Journal, lxxi, 522.)
LANE, C. . . .	Further note on Bursati Nematodes from the Indian Elephant. (Ind. Journ. Med. Res., iii [1915], 105.)
NORIS, R. V. . .	A comparison of the "Defibrination" and "Oxalate" methods of serum Preparation as applied to Hæmorrhagic Septicæmia and Anthrax sera together with some Analysis of Buffalo and Hill Bull Blood (In the Press). (*Bull No. 60, Agr. Res. Inst., Pusa.*)
SHILSTON, A. W. .	A note on the Diagnosis of Glanders. (*Agr., Journ., Ind., xi, 65.*)
SHILSTON, A. W. .	Protective Inoculation of Stock in India. (*Agr. Journ., Ind., xi, 112.*)
SHILSTON, A. W. .	Rinderpest, preparation of Anti-Serum. (In the Press.) (*Bull. Agr. Res., Inst., Pusa.*)

MEDICAL RESEARCH.

Indian Research Fund.

At the fourth annual meeting of the Governing Body held at Simla on the 31st March 1915, the following members were appointed to serve on the Scientific Advisory Board :—

(1) Surgeon-General Sir Pardey Lukis, K.C.S.I., K.H.S., I.M.S.

(2) Lieutenant-Colonel J. C. Robertson, C.I.E., I.M.S.

(3) Major S. R. Christophers, C.I.E., I.M.S.

(4) Major F. Norman White, I.M.S.

The activities of the Association have been naturally hampered by the war: a considerable amount of useful work has, however, been carried out.

The investigations that have been in progress during the year relate to cholera; kala-azar (in Madras); dysentery; the prevalence of tuberculosis in India; the prevention of plague; the bacteriological examination of water; diabetes; the bionomics of the common house-fly; and osteomalacia.

Cholera.—Major Greig's investigations on the subject of cholera, which were prosecuted for five years, were brought to a close on that officer's reversion to military duty on the 28th of February 1916. Eighteen reports detailing the results achieved have been published during the last three years in the *Indian Journal of Medical Research.* These reports form a most important addition to the literature of the subject, and have added materially to our knowledge of cholera, and cholera-like, vibrios. The Scientific Advisory Board take this opportunity of expressing their appreciation of the skill and enthusiasm that Major Greig has devoted to a most difficult research.

Kala Azar.—The closing of the kala-azar investigation in Assam was reported at the last annual meeting. Major Mackie, I.M.S., who was employed on this investigation has contributed two further papers to the *Indian Journal of Medical Research* dealing with the presence of *Leishmania* in the peripheral blood of cases of kala-azar in Assam and the experimental transmission of Indian kala-azar to animals.

The investigation in Madras City was brought to a close on the 31st of March 1915. Dr. Korke who was engaged on this inquiry under the kala-azar sub-committee was transferred to the Central Research Institute, Kasauli, where he continued to work on cognate subjects. A report by him on a Nosema (*Nosema pulicis* n. s.) parasitic in the dog flea has been published in our Journal. The observations therein described are of considerable interest.

Dysentery.—Owing to the recall of Captain J. Cunningham, I.M.S., to military duty, the dysentery inquiry in Bengal was brought to a close on the 20th of April 1915. Captain Cunningham has recently been transferred to the Central Research Institute, Kasauli, as Director, and is at present engaged upon his final report.

The Prevalence of Tuberculosis in India.—Dr. Lankester, M.D., continues his inquiry into the prevalence of tuberculosis in India. He has submitted a preliminary report, copies of which have been forwarded to the Governing Body. The Scientific Advisory Board are not at present prepared to commit themselves to an expression of opinion as to the validity of all the deductions drawn by the author or the desirability of some of the measures advocated. The Board's suggestion that copies of the report be sent to each of the local Governments, explaining its provisional nature and inviting criticism, has been acted upon by the Governing Body. The considered opinion of local Governments upon the issues raised should be most helpful both in suggesting lines for further inquiry and measures for the amelioration of existing conditions.

The Prevention of Plague.—Major Kunhardt, I.M.S., who was in charge of this inquiry reverted to military duty on the 20th of April 1915, and Dr. Chitre was placed in charge.

It is by no means easy to gauge the measure of success that has hitherto attended this important experiment. Major Kunhardt's contention, that it is possible, in the non-epidemic season, to identify towns and villages that will act as dangerous foci for dissemination of infection in the following epidemic, has received a certain amount of confirmation. In the matter of dealing with such places, however, the measures hitherto employed must be stigmatized as inadequate. The systematic setting of poisoned baits (common sense rat exterminator) has been the measure chiefly employed, and has failed to effect the necessary reduction in the rat population. This failure must be attributed to two facts :—

(1) phosphorous rat poisons though very lethal cannot be made sufficiently attractive to rats ;

(2) the area under experimentation, consisting of four districts, Poona, Satara, Ahmednagar and Sholapur, was too large to allow of as effective supervision by the supervising staff as the nature of the operations necessitates.

Moreover, it must be acknowledged that abnormal meteorological conditions have made the non-epidemic season much less unfavourable to the continuance of plague infection than is usually the case.

The Scientific Advisory Board have decided, therefore, to curtail the field of inquiry to the Poona district and to employ there more thorough measures of rat extermination. More thorough supervision in this area will be practicable and incidentally the cost of the experiment will be considerably reduced.

Experiments with barium carbonate offer promise that in this drug we have a more efficient rat poison than any hitherto employed.

Preliminary experiments have also been carried out with hydrocyanic acid gas as a plague disinfectant for Indian village dwellings. As far as they go, this method promises to be of only limited applicability. The impossibility of

making the Indian house of the poorer type anything like air-tight vitiates the method in such cases. Experiments are still going on and the results achieved will be reported in due course.

The Bacteriological Examination of Water.—Captain J. Morison, I.M.S., continued his inquiries in connexion with the bacteriological examination of water in Poona during the year. On the 24th of April last he reverted to military duty handing over the charge of the inquiry to Mr. Fox with instructions to close it down. The inquiry has yielded results of very great importance to Poona itself, and has added to our knowledge of the mechanism of water-borne diseases. Not only has Captain Morison been able to demonstrate that the monsoon diarrhœa and dysentery of Poona owe their origin to a contaminated water supply, he has also demonstrated that at a comparatively trifling cost it is possible to diminish very largely, if not to eradicate completely, the mortality which year after year has been caused by these conditions. Two reports have already been published and three others are approaching completion.

Diabetes.—Major D. McCay, I.M.S., Professor of Physiology, Medical College, Calcutta, has been prosecuting an inquiry into the prevalence and etiology of diabetes in Bengal. In compliance with the request of the Government of Bengal, sanction has recently been accorded to the continuation of the investigation for a further period of one year. A preliminary report has recently been received in which are described some very valuable observations on the sugar content of the blood of the Bengali and the relation which this bears to the prevalence of glycosuria. These observations indicate why diabetes and like conditions are relatively so common amongst the Bengalis : diet and mode of life appear to be the important causes of the excessive prevalence.

Entomology.—Mr. P. R. Awati, Medical Entomologist employed under the Indian Research Fund Association, has continued his investigation on the subject of flies. Two contributions from his pen have been published in the Journal and a third has just been received. He is working on promising lines, and a welcome addition to our knowledge of the genus *Musca* can be looked for with confidence The work is of very great importance, as an increased knowledge of the bionomics of the various species of house-fly must lead to a clearer conception of the role played by flies in the dissemination of infection of intestinal diseases. More exact knowledge on this important subject is much needed.

Entomological Assistants.—Of the two entomological assistants employed by the Association, (1) Mr. Swaminath has been assisting Mr. Awati and (2) Mr. Mitter has been employed at the Central Research Institute, Kasauli, on various entomological problems. Owing to the lack of sufficient material at Kasauli in the cold weather, Mr. Mitter was permitted to work at Ambala for a period of four months. Mr. Mitter has contributed three entomological notes to our Journal.

Ankylostomiasis.—An inquiry into the prevalence of hook-worm disease in the Darjeeling district has been carried out under the supervision of Major Clayton Lane, I.M.S., Civil Surgeon, Darjeeling. Up to the 10th of March 1916, 11,234 persons had been examined and a very large percentage of them were found to be infected with *Necator americanus*: all the latter received treatment. It is too early yet to give figures demonstrating the amount of inefficiency directly attributable to hook-worm infection amongst the tea-garden labour population, but that it is very considerable there cannot be the least doubt. The investigation is to be continued for a further period of six months on existing lines.

The popular pamphlet on the subject of hook-worm disease, referred to in our report for last year, was in considerable demand; 9,307 copies have been printed and distributed. The pamphlet has also been translated into Nepalese for circulation in the Darjeeling district.

The Governing Body are aware that this hook-worm investigation was undertaken in response to a request made by the International Health Commission of the Rockefeller Foundation, United States of America. The 'Director for the East' of this Commission is very anxious that we should start work on similar lines in Madura or some adjacent district in Southern India. The possibility of being able to do this at an early date is under the consideration of the Board who will address the Governing Body shortly regarding this matter.

Osteomalacia.—An inquiry into the prevalence of this disease in India was started by Dr. Agnes Scott on the 1st of October 1915. Dr. Scott has completed a preliminary inquiry and has submitted a report. Osteomalacia is a disease of unknown origin, the most striking symptom of which is softening and deformity of the bones. This deformity often leads to serious difficulty in child-birth. Many hypotheses have been advanced as to the causation of this interesting condition, but none are entirely satisfying. That the disease is certainly ten times more common amongst women than men lends support to the view that pregnancy and disorganized genital functions of the female may be factors of importance in its causation: that they are all important is negatived by two facts, *viz.*:—

(*a*) the disease can and does occur in men,

(*b*) the disease has a well-marked geographical distribution.

This last fact is important to bear in mind. For instance, the relative frequency with which the condition is met with in Southern Europe, and its almost complete absence in Northern Europe, discount many of the theories of causation that have been advanced.

For long it has been recognised that the disease is wide-spread in India and relatively common, but no exact information was available. Dr. Scott's inquiries have shown that there is a well-marked geographical distribution of the disease in India. With the exception of Kashmir, where the disease

exists, all the areas of India in which *rice* is the staple diet are free from the disease. In Northern India the disease is specially common amongst the Banias and Khatris ; in Western India the Boras are most susceptible. No record of a case occurring in the male sex has been discovered in India. The age of incidence is lower amongst Indian than amongst European women. These are the chief facts that have emerged from the investigation. Although no definite information regarding the etiology of the disease has been forthcoming, this preliminary inquiry clears the way for further investigation.

Leprosy.—The number of preparations whose claims have been advanced during recent years as cures for leprosy indicates that, at present, we have not found a specific for this disease. Chaulmoogra oil was one of the earliest in the field and it still has a number of adherents. Though its ability to cure the disease is open to grave doubts, it does appear to retard its progress. Being a gastro-intestinal irritant, its use is attended with many drawbacks, but recent improvements in methods of administration have removed most of these. The active principle of the oil is gynocardic acid. Quite recently Sir Leonard Rogers has put forward a claim that salts of this gynocardic acid give very much better results than treatment with the crude oil. He has been assisted in his investigations by Dr. Sudhamoy Ghose. The Governing Body have been pleased to approve the proposal of the Scientific Advisory Board to give a grant of Rs. 250 a month towards the expenses of this investigation.

Hydrocyanic Acid Gas as a Plague Disinfectant.—A further grant of Rs. 3,000 was made during the year to the Director of the Bombay Bacteriological Laboratory to enable him to complete his experiments with hydrocyanic acid gas as a disinfectant for plague. Brief reference has been made to this subject in the section which deals with plague. Its use as a disinfectant for the ordinary dwelling house is attended with certain drawbacks, the most important of which are the limited diffusibility of the gas, the cumbersome nature of the apparatus, and the amount of time which it is necessary to expend on each dwelling. With care the method is free from danger, and it is gratifying to note that hitherto the people have shown no opposition to its use. On the contrary, they welcome it, as whatever doubts may be cast on its efficiency as a plague disinfectant, it certainly rids houses of bugs and other vermin. For *pucca* dwellings, grain stores and the like, this method promises to be of very considerable value.

Nurse Visitors in Delhi.—The two nurse visitors, whose pay and expenses are provided by the Research Fund Association, continue to do excellent work in Delhi. It may be that the welcome fall in the excessive infantile mortality, that was evidenced last year, was not unconnected with their efforts.

Protozoology.—Mrs. Adie continues her investigations at the Central Research Institute, Kasauli, on a leucocytozoon of birds. Her work is making satisfactory progress.

The Indian Journal of Medical Research.—The Journal has now completed the third year of its existence. The four numbers that go to make up Volume III contain 49 original articles, many of them being of very considerable importance. The fears, that were freely expressed, that we should lack sufficient material to enable us to continue on the somewhat ambitious lines on which we embarked three years ago, have been completely falsified, and this despite the disorganization of research that has naturally accompanied the prolongation of the war. The thanks of the Board are due to our numerous contributors who have between them assured for our Journal that large measure of success which we can indubitably claim for it. Certain of the articles that have been published are of quite exceptional value and, without wishing to draw invidious distinctions, we may cite Greig's papers on cholera, Morison's articles on water supplies, and Christophers' contributions on malaria, as certain to take a prominent place in the literature of the subjects with which they deal. The appreciations of the Journal that have from time to time appeared in the foreign press have been the source of much gratification and encouragement to the Board.

Grants sanctioned by the Governing Body during 1915-16.

Special reference may also be made to the following items of expenditure :—

	Rs.
Grant for the establishment of model grain godowns and other experimental sanitary measures for Lucknow in connection with the rebuilding scheme	80,000
Grant for certain additions to the building of the School of Tropical Medicine, Bombay	1,00,000
Further grants for purchase of books for the Central Malaria Bureau	500
Grant in connexion with the raising of the "Bela" in Delhi with reference to malaria	1,50,000
On account of expenditure incurred in publication of translation of the pamphlet on hook-worm disease	463
Grant to the Imperial Bureau of Entomology (£500 per annum for 3 years)	7,500
Additional grant for experiments for improving the malarial conditions of a part of Delhi	50,000
Additional grant for the completion of the antimalarial schemes in Saharanpore and Nagina	52,216
Purchase of scientific journals for Divisional and Brigade laboratories	300
Grant-in-aid of the research portion of the new Pasteur Institute, Shillong	25,000

Recommendations for 1916-17.

Owing to the scarcity of trained research workers it is not possible for us to recommend to the Governing Body, at present, any fresh schemes of research.

We recommend, however, the continuation of the following inquiries, on existing lines :—

(*a*) Tuberculosis (Dr. Lankester).

(*b*) Plague prevention (Dr. Chitre).

(*c*) Bionomics of the house-fly (Mr. Awati).

(*d*) Diabetes (Major McCay).

(*e*) Ankylostomiasis or hook-worm disease (Major Clayton Lane).

(*f*) Leucocytozoa (Mrs. Adie).

The Board wish to place on record their appreciation of the valuable services rendered by the office staff, more especially by Mr. Stuart Wilson, Chief Superintendent, Mr. Buller-Wade in charge of the Sanitary Section, and Pundit Babu Ram, Research Fund Clerk.

APPENDIX.

Report on the Principal work conducted for India at the Imperial Institute during the year ended 30th June, 1916.

SCIENTIFIC AND TECHNICAL RESEARCH DEPARTMENT.

I.—SCIENTIFIC INVESTIGATIONS.

Aconites.—The examination of the alkaloids of the several species of Indian aconites mentioned in last year's report has been continued.

Essential Oils.—An authentic sample of oil prepared in Southern India from "white-stemmed" lemongrass was forwarded to the Imperial Institute, together with a herbarium specimen of the grass, in continuation of a previous investigation of supposed "white-stemmed" lemongrass oil. The grass was identified at Kew as *Cymbopogon flexuosus*, Stapf, *f. albescens*, a colour variety of *C. flexuosus*, the recognised source of Cochin lemongrass oil. The oil proved to be a normal lemongrass oil, and was quite different from the previous sample, which was of the citronella type, although forwarded as "white-stemmed" lemongrass oil. The investigation further showed that the occasional "insolubility" of Cochin lemongrass oil is not caused by the chance inclusion with the typical Cochin lemongrass (*C. flexuosus*) of other wild grasses yielding an "insoluble" oil, but that it is probably due to the distillation being carried too far, so that "insoluble" constituents are included in the distillate.

A sample of "Shiah Zira" fruits (*Bunium Aitchisonii*) was found to yield on distillation 3·3 per cent of a pale yellow volatile oil, with an odour similar to that of cumin oil, but also recalling that of lemons. The quantity of oil obtained was too small for complete investigation, but a preliminary examination showed it to contain 35 per cent. of aldehydes, chiefly or entirely cuminic aldehyde, and a crystalline alcohol melting at 136°C. A further supply of the fruits has been asked for in order that the examination of the oil may be completed.

Foodstuffs.—Samples of Madagascar beans grown experimentally in Burma, representing the first, second and third year's produce from seed supplied by the Imperial Institute, were examined in order to determine the effect of continued cultivation upon the amount of prussic acid yielded by the beans. It was shown that the amount of prussic acid does not appear to be influenced very greatly by soil conditions, but that it is probably much affected by the weather conditions of the growing season. Although these beans have now been grown experimentally for three years in Burma they show no signs of yielding more than the mere traces of prussic acid also found in the beans as imported from Madagascar.

A sample of *Phaseolus lunatus* beans grown experimentally in Burma from American seed was also examined. The amount of prussic acid yielded by these beans was greater than in the case of any of the Madagascar beans grown in the same season, and it will be interesting to note how this variety behaves in succeeding seasons.

II.—TECHNICAL AND COMMERCIAL INVESTIGATIONS.

A.—Experimental Work.

Cotton.—Samples of five varieties of cotton (Cambodia, Rosea, Buri, and the hybrids Bani x Rosea and Bani x Deshi Lahore) which were stated to have been grown under irrigation at the Experimental Farm, Sindewahi, Central Provinces, were submitted for examination. The Cambodia cotton was of satisfactory quality and strength, but rather irregular in length; the Rosea cotton was short, but of good strength, and gave a remarkably good yield on ginning; the Buri cotton was on the whole of satisfactory quality but of rather irregular length and strength; the hybrid Bani x Rosea was of good strength but short; whilst the Bani x Deshi Lahore ("Sindewahi Cross") represented a cotton of very satisfactory quality. In view of the fact that the last-named cotton gives a large crop and a high yield on ginning, its cultivation should prove successful, provided that the quality can be maintained by the ordinary cultivators. The five samples were valued respectively at 7·75*d.*, 6·50*d.*, 7·00*d.*, 6·75*d.*, and 7·25*d.* per lb., with "middling" American at 7·50*d.* per lb. A further sample ("K7") grown on the same farm was of rather short staple and somewhat uneven in strength, and was valued nominally at 6*d.* per lb. on the same date.

Nine samples of cotton were received from the Experimental Farm at Akola, Berar, representing the following varieties:—Rosea, Malvensis, Bani Buri, Saugar Jari, Berar Jari, Cutchica, Vera, and Bani x Deshi Lahore. The cottons were on the whole very clean and of good quality, and closely resembled previous samples from the same source; in some cases they showed a decided improvement in length. They were valued respectively at $4\frac{3}{8}d.$, $4\frac{5}{8}d.$, $5\frac{3}{4}d.$, $5\frac{1}{2}d.$, $4\frac{5}{8}d.$, $4\frac{1}{2}d.$, $4\frac{3}{8}d.$, $4\frac{1}{2}d.$ and $4\frac{3}{4}d.$ per lb., with "middling" American at 5·25*d.* per lb.

Samples of Buri, Yellow-flower, Varhadi and Cutchica cottons from the Eastern Circle, United Provinces, were also examined. The Buricotton was of rather irregular strength, but fair on the whole, and the Yellow-flower, Varhadi and Cutchica cottons were also fairly strong. All four samples had suffered from insect attack, causing stains in the lint. The Buri cotton was valued at 4·5*d.* and the other three varieties at 4·25*d.* per lb., with "fully good" Sind and Bengal cotton at 4·68*d.* and "fully good fair" Broach at 6·3*d.* per lb. All the samples were short in staple, and such cottons would be quite suitable for use in the Indian mills where the machinery is generally adapted for spinning short staples. Attention should however, be devoted

to improving, by selection methods, the length of the " Buri " cotton, of which rather longer-stapled samples have been previously examined at the Imperial Institute, so as to render it suitable for the Lanchashire industry.

Foodstuffs.—A sample of Tepary beans (*Phaseolus acutifolius*) from Burma was submitted for examination and valuation. The beans contained no alkaloids or cyanogenetic glucosides, and possessed a high food value, comparing favourably with haricot beans, lentils and peas, which they resembled in composition. A firm of merchants stated that the beans should find a ready market in the United Kingdom and some of the Allied countries, and valued them at about £22 to £23 per ton(February 1916), adding, however, that the pre-war price would have been only about £10 per ton. The firm considered that the beans might be acceptable as a substitute for small white haricot beans, and in that case they should be a valuable export crop for Burma, if they grow well and give good yields.

Five samples of Madagascar beans grown in Burma were valued at prices ranging from 22*s*. to 28*s*. per cwt. c.i.f. London (March, 1916). The beans were on the whole inferior to those imported from Madagascar, but if of uniform size, good colour and shape it might be possible to market them successfully as a distinct grade.

A sample of *Phaseolus lunatus* beans grown in Burma from American seed was much inferior to Californian Lima beans, particularly as regards size, and was valued by a firm of merchants at 18*s*. to 20*s*. per cwt., c.i.f. London (March, 1916) compared with a pre-war price of about 7*s*. per cwt. A second firm considered that the beans might be regarded as a distinct variety, which would complete with flat Danubian beans, and valued them at about £25 per ton in London (March 1916), with a pre-war price of at least £12 to £14 per ton.

Oilseeds.—A sample of black soy beans from Sind gave a normal yield of oil for this variety. The beans were valued at about £14 per ton exship Hull, *i.e.*, about 5*s* to 10*s*. less than the price then ruling for yellow soy beans, owing to the fact that the residual cake and meal from the black beans are not so readily saleable in the United Kingdom as those from the yellow variety.

A sample of soy beans from Madras was found to give a rather low yield of oil and for this reason was valued at about 10*s*. per ton below the price of Manchurian soy beans, which were currently quoted at £8 per ton on the spot in Hull.

The preference in the United Kingdom is in favour of the light-coloured varieties of soy beans, and it is therefore desirable to cultivate the yellow variety for export.

A sample of unshelled ground nuts was received from Madras and the kernels were found to yield the satisfactory amount of 48·6 per cent of oil. A firm in London valued the sample at about £10 per ton c.i.f. Marseilles (July 1915) adding that British buyers might also purchase these ground nuts, but probably at not more than about £9 per ton. A second firm described the sample as ordinary Coromandel ground nuts and valued them at

£13 10s. to £14 per ton (July, 1915), but it is probable that this price could only be realised for small selected lots.

Soap nuts.—A sample of Sapindus fruits (soap nuts) was found to contain 4 per cent. (expressed on the entire fruits) of a yellow mobile oil, which is too small a yield to render them of value in Europe as an oilseed. The rinds of the fruits appeared to be slightly superior in emulsifying power to quillaia bark, but a firm who use such materials for the manufacture of insecticides stated that the Sapindus fruits would probably not realise more than £7 per ton landed at an English port (February, 1916). Another firm, however, stated that there is a growing market in the United Kingdom and the Colonies for such materials, and they valued the rinds (*i.e.*, the fruits without the nuts) at from 25s. to 30s. per cwt., c. i. f. Liverpool (February, 1916).

Resin.—The resin of *Hardwickia pinnata* was examined as a varnish material, and was found to produce a very slow drying varnish with turpentine oil. Resin represented by the sample would be very difficult to dispose of, as it could only be used industrially as a substitute for lowgrade colophony.

B.—The Technical Information Bureau.

The work of the Bureau has been continued on the lines indicated in last year's report. Information on technical and commercial subjects has been furnished to Government Departments in India, and a large number of enquiries have been answered from merchants and others interested in Indian produce and trade in the United Kingdom and abroad. The nature of the enquiries thus dealt with is illustrated by the following examples.

Mussel Shells.—An enquiry as to the types of mussel shells used for button making in Europe and America was received from the Honorary Director of Fisheries in Madras, who was considering the questions of the possible utilisation for this purpose of the fresh water and other mussels which occur in Madras, and the cultivation of suitable varieties in the fish farm established by the Department. In response to this request the Bureau forwarded to India a complete set of the mussel shells which are used in the button-making industry, together with information regarding the different species of shell and the machinery used for cutting and finishing the buttons. Reports were also furnished on specimens of Indian mussel shells, some of which would be suitable for button-making.

In addition, information was supplied to the Madras Fisheries Bureau regarding the prices of trocas and snail shells and the names of firms able to supply them.

Beeswax.—The attention of the Government of India was called by the Bureau to the extensive adulteration of Indian beeswax, which was seriously interfering with its possible use in Russia for church purposes. There is a very large demand for beeswax in Russia for the manufacture of church candles, but it is essential that the wax employed should be free from adul-

teration. After the outbreak of war the authorities of the Russian Church withdraw their prohibition of Indian beeswax, but owing to the difficulty of obtaining commercial consignments of pure Indian beeswax very little advantage could be taken of the new market thus offered. It is hoped that as a result of the publicity given to this question in India supplies of pure beeswax will be forthcoming in the future. The buying agents of the Russian Church in London have already been put into communication with a firm in Calcutta who state that they are in a position to supply the unadulterated wax.

Madras Handkerchiefs.—Samples of Madras handkerchiefs were received from the Director of Industries, Madras, who desired to obtain information regarding possible markets for such goods, of which stocks were stated to be available in India. The handkerchiefs appeared to be suitable for the West African market, and were therefore submitted by the Bureau to several firms trading with West Africa. Information was transmitted to India regarding the qualities of handkerchiefs most required in the West African trade and the prices obtainable, together with an offer from a firm in the United Kingdom to purchase a consignment of the handkerchiefs.

Thymol.—Reference was made in last year's report to the action taken by the Bureau with a view to establishing in the United Kingdom the manufacture of thymol from Indian ajowan seed. As a result of this action thymol is now being made by several British firms. A further statement on the subject of the preparation of thymol was issued by the Imperial Institute during the year under notice, giving particulars of a method worked out in the Scientific and Technical Department for producing thymol in the large transparent crystals formerly supplied by the German manufacturers. Information on the preparartion of thymol was furnished to several enquiriers in India, and the names of firms able to supply plant for the purpose were given to the Director General of Commercial Intelligence, Calcutta.

Information was also furnished during the year to Indian Government Departments on a number of other technical and commercial questions, including the following :—The preparation of a bleaching solution from brine ; methods of extracting potash from felspar ; special methods of retting flax used in Europe ; the preparation of lime juice ; the market for sandal-wood oil ; the market for rosewood ; special methods of tanning ; the preservation of timber ; the plant and fuel required for glass manufacture ; the registration of a trade mark in the United Kingdom ; the organisation of commercial museums ; and Indian trade interests in France. Assistance was also rendered in selecting technical officers for special service in India.

In addition a large number of enquiries relating to India and Indian products have been dealt with for firms and individuals in the United Kingdom and India. These have included the following subjects :

Ground nuts, copra, mowra seed and cake, castor seed and oil, cashew nuts, safflower seed oil, ghee, methods of refining oils, opium, *Hyoscyamus*

muticus, *Cannabis indica*, Datura seed, cardamoms, chaulmoogra seed, khus-khus, soap nuts, milk-sugar, indigo, hides and skins, lac, thitsi (Burmese lacquer), bristles, dari, rice, paddy husks, Rangoon beans, honey, cotton, kapok, ramie, Hibiscus fibre, Calotropis fibre, bamboos for paper making, silk, wool, monazite sand, potash deposits, coal, wolfram, saltpetre, corundum mica, ochres and magnesite.

During the year under notice a monograph entitled " Oil Seeds and Feeding Cakes " was prepared by the Bureau and published by Mr. John Murray. This monograph gives full information regarding the trade in copra, ground nuts, sesamé seed and mowra seed, products which are of special importance in India, and also deals with the industrial uses of the oils and the feeding values of the cakes. The book has already had a large circulation.

Mention may also be made of a publication on " The World's Supply of Potash," which was issued by the Bureau. This publication deals with the existing and undeveloped sources of potash throughout the world, including those in India.

A number of articles relating to Indian economic products were published during the year in the " Bulletin of the Imperial Institute," the most important being the following :—The Work of the Imperial Institute for India ; Indian Opium ; Edible Beans from Burma ; Turpentine Oil and Resin of *Boswellia serrata*, Production and Utilisation of Rape Seed ; and Cultivation and Utilisation of Niger and Safflower Seed. In addition briefer notices were published on various Indian products, among which may be mentioned wheat, Sugar, Cashew Nuts, Coconuts, Rubber, Cotton, Jute, Silk, Timbers and other Forest Products, Soils, Coal and Potash.

List of materials received at the Imperial Institute from Government Officers in India during the year ended 30th June 1916.

Title of Officer.	Material sent.	Number of samples.
Forest Economist, Dehra Dun	Deodar Oil	1
Do. do.	Resin	1
Do. do.	Gum	3
Do. do.	Grass oils	2
Fibre Expert to the Government of Bengal.	Nettle fibre	1
Superintendent, Benares Opium Agency, Ghazipur.	Morphine hydrochloride	5
Superintendent, Benares Opium Agency, Ghazipur.	Codeine	6
Superintendent, Benares Opium Agency,	Opium	15
Hon. Director of Fisheries, Chepauk, Madras.	Mussel shells	1
Deputy Director of Fisheries, Bengal	Do.	2
Director of Agriculture and Industries, Punjab.	Soap nuts	1

List of materials received at the Imperial Institute from Government officers in India during the year ended 30th June 1916.

Title of Officer.	Material sent.	Number of samples.
Director of Agriculture, Madras	Lemongrass	1
Do. do.	Lemongrass oil	1
Do. do.	Tobacco	2
Director of Agriculture, Mandalay, Burma.	Beans	7
Deputy Director of Agriculture, Southern Circle, Central Province.	Cottons	6
Deputy Director of Agriculture, Mirpurkhas, Sind.	Soy beans	1
Deputy Director of Agriculture, Insein, Burma.	Tobacco	5
Assistant Director of Agriculture, Eastern Circle, United Provinces.	Cottons	4
Superintendent, Experimental Farm, Akola, Central Provinces.	Cottons	12
State Geologist, Trevandrum, Travancore.	Minerals	6

List of Reports made by the Imperial Institute to Government Officers in India during the year ended 30th June 1915.

Officers to whom Reports were sent.	Subject of Reports.
Forest Economist, Dehra Dun	*Hardwickia pinnata* resin.
Director, Botanical Survey of India.	"Shiah Zira" fruits (*Bunium Aitchisonii*).
Factory Superintendent, Benares Opium Agency, Ghazipur.	Morphine hydrochloride and codeine.
Director of Agriculture, Mandalay, Burma	"Tepary" beans (*Phaseolus acutifolius*).
Do. do.	Madagascar beans.
Do. do.	*Phaseolus lunatus* beans.
Director of Agriculture, Madras	Lemongrass and lemongrass oil.
Do. do.	Soy beans.
Director of Land Records and Agriculture, United Provinces.	Cottons.
Director of Agriculture and Industries, Punjab	Soap nuts (Sapindus fruits).
Director of Industries, Madras	Ground nuts.
Do. do.	Madras handkerchiefs.
Director of Agriculture, Central Provinces.	Cottons.
Deputy Director of Agriculture, Mirpurkhas, Sind	Soy beans.
Deputy Director of Agriculture, Southern Circle, Central Provinces.	Cottons.
State Geologist, Trevandrum, Travancore	Minerals.
Hon. Director of Fisheries, Chepauk, Madras.	Mussel shells.
Deputy Director of Fisheries, Bengal.	Mussel shells.

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Departmental Publications.

I.—METEOROLOGICAL DEPARTMENT—

Government of India Office.

(1) The Indian Daily Weather Report and Chart.
(2) The Weekly Rainfall Summary.
(3) The Monthly Weather Review.
(4) The Annual Summary.
(5) The Rainfall of India.
(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.
(2) Monthly Rainfall Tables and Summaries of the chief feature of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Rainfall Tables (*Madras Gazette*).

Allahabad Office.

(1) Monthly Weather Summaries (*United Provinces Gazette*).
(2) Annual Summary.
(3) Monthly Rainfall Tables (*United Provinces Gazette*).

Lahore (Simla) Office.

(1) Monthly Summary } of Punjab weather.
(2) Annual Summary }

II.—GEOLOGICAL SURVEY.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I.—XLIII, including the larger papers on geological subjects.

Records, Vols I.—XLVIII, including the shorter papers and Annual Reports from 1868 to 1915, sold in parts, price one rupee each.

Manual, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

Indexes to the Genera and Species described in the *Palæontologia Indica* up to 1891, to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

III.—SURVEY OF INDIA.

(1) Annual General Report.
(2) Professional Papers.

IV.—BOTANICAL SURVEY AND ROYAL BOTANIC GARDEN, CALCUTTA.

(1) Annual Report of the Botanical Survey of India.
(2) Records of the Botanical Survey, Vols. I—VIII.
(3) Annual Report of the Industrial Section, Indian Meseum.
(4) Annual Report of the Royal Botanic Garden, Calcutta.

(5) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII.

A list of the contents of the Records and of the Annals with prices of the numbers and volumes still available can be obtained by applying to the Superintendent, Royal Botanic Garden, Calcutta.

V.—DEPARTMENT OF AGRICULTURE.

(1) Annual Report.—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology, and the like).

(2) The Agricultural Journal of India.—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.

(3) Scientific Memoirs of the Department of Agriculture.—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.

(4) Bulletin.—An occasional publication containing information on agricultural matters of a temporary nature.

(5) Leaflets.—Short notes of practical instruction in agricultural matters, dealing mainly with entomological subjects.

VI.—FOREST DEPARTMENT.

(1) Review of Forest Administration in British India by the Inspector-General of Forests (issued annually).

(2) Annual Progress Report of Forest Administration in each Province.—Issued by the Local Governments annually.

(3) Indian Forest Records.

(4) Indian Forest Memoirs.

(5) The Indian Forester.—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal, published monthly.

(6) Bulletins are published from time to time.

VII.—ZOOLOGICAL DEPARTMENT.

(1) The Annual Report, 8vo.

(2) The Records of the Indian Museum, 8vo. Containing short papers on Indian zoology. One or two volumes issued annually in quarterly parts.

(3) The Memoirs of the Indian Museum, 4to. Containing monographs and other important papers. Published at irregular intervals.

(4) Descriptive Catalogue of Indian Decapod Crustacea, 4to. Parts published at irregular intervals.

(5) Descriptive Catalogue of Indian Echinodermata, 4to. Parts published at irregular intervals.

VIII.—CIVIL VETERINARY DEPARTMENT.

(1) Annual Report.

CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.